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Transportation Controls to Reduce Motor Vehicle Emissions in Major Metropolitan Areas

GCA Corp.

**prepared for
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**TRANSPORTATION CONTROLS
TO REDUCE MOTOR VEHICLE
EMISSIONS IN MAJOR
METROPOLITAN AREAS**



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**TRANSPORTATION CONTROLS
TO REDUCE MOTOR VEHICLE
EMISSIONS IN MAJOR
METROPOLITAN AREAS**

by

GCA Corporation
GCA Technology Division
Bedford, Massachusetts

and

TRW Inc.
Transportation & Environmental Operations
McLean, Virginia

Contract Nos. 68-02-0041
68-02-0048

EPA Project Officer: Frederick Winkler

Prepared for

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Office of Air and Water Programs
Office of Air Quality Planning and Standards
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December 1972

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Alan M. Voorhees Associates, Wilbur Smith Associates, and ABT Associates acted as subcontractors to GCA Technology Division and supplied major input to the study especially in the areas of traffic data, control strategies and implementation obstacles. DeLeuw, Cather and Company, a TRW subsidiary, provided similar inputs and assistance to TRW.

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1.0 INTRODUCTION

1.1 PROGRAM PURPOSE AND DESCRIPTION

Eighteen States must submit definitive transportation control plans to the Environmental Protection Agency (EPA) no later than February 15, 1973, for those areas of the State where emissions from transportation sources have resulted in concentrations of pollutants in excess of the national ambient air quality standards. To assist the States in the preparation of these transportation plans, EPA has awarded contracts to TRW Inc., and its subsidiary De Leuw, Cather and Company and GCA and its subcontractors, Alan M. Voorhees Associates, William Smith Associates, and ABT Associates, to develop strategies for fourteen metropolitan areas that will achieve carbon monoxide and oxidant air quality standards required to be met by the year 1977. In the performance of this program the following tasks were performed:

1. Implementation Plan Review to verify and assess the severity of the carbon monoxide and oxidant pollutant problem.
2. Identification of Transportation Controls. These strategies considered the impact of the required 1975 motor vehicle controls on carbon monoxide and hydrocarbon emissions as well as the assessment of the feasibility of achieving control as established by the Six Cities Study.
3. Estimate of Air Quality Impact. Estimate of the likely impact anticipated from each of the control techniques using established rollback or modeling methods.
4. Documentation of Implementation Obstacles. The contractor met with local air pollution and transportation agencies responsible for implementing the recommended controls for the purpose of identifying obstacles that can be expected in the implementation process.
5. Formulation of Surveillance Review Process. The formulation of a timetable of key checkpoints to be used by EPA in monitoring implementation progress in achieving transportation control. The timetable includes the period January 1973 through December 1976.

Those metropolitan areas specifically investigated are listed below:

TRW (DCCO)

Dayton
Denver
Houston/Galveston
Los Angeles
New York City
Philadelphia
Phoenix/Tucson

GCA, Voorhees, Smith, and ABT

Baltimore
Boston
Pittsburgh
Salt Lake City
Spokane
Seattle
Minneapolis/St. Paul

Detailed individual reports were prepared for each metropolitan area. This document is intended to be used in conjunction with these reports as a guide for the development of transportation strategies for metropolitan areas having similar air pollution problems. Section 2.0 discusses the general methodologies employed and Section 3.0 highlights the air quality problems encountered in the fourteen metropolitan areas and the recommended transportation strategies.

1.2 LIMITATIONS OF THE TRANSPORTATION CONTROL STRATEGY ANALYSIS

The basic requirement which any acceptable air pollution control strategy must meet is that emission levels following implementation of the strategy are consistent with the attainment and maintenance of National Ambient Air Quality Standards. Satisfaction of this requirement depends upon a detailed knowledge of current air quality levels and a quantification of the pollutant emissions in the region. Additionally, an implementable transportation control strategy must consider the economic factors associated with its adoption and also the social and political changes necessary to accommodate each specific control measure. The air quality benefits of any action must be thus balanced against the social and economic dislocations caused by its implementation. Long-term regional transportation goals and policies must be balanced against the need to achieve specific degrees of emission reduction by 1977. Limitations in the data available and in the analytic method used became obvious during the course of this study, and care must be taken in the interpretation and evaluation of the control strategy recommendations contained in this report. Several specific areas in

which the present study needs to be confirmed and validated by future study are listed below.

1.2.1 Air Quality Monitoring

Two basic areas of concern appear in connection with air quality data available for this project. First and most important, ambient monitoring at only one point completely fails to give an adequate appreciation of the regional character of the air pollution problem. It is impossible to determine whether the monitor is being adversely affected by local sources and thus giving unrealistically high readings in terms of the regional problem or conversely, whether there are areas of maximum ambient pollution that are being completely unmonitored. The only solution to this problem lies in increasing the number and geographical spread of ambient monitors. Data from the extended monitoring network should be used to constantly evaluate and update the control strategy presented in this document. The second problem concerning the use of air quality monitoring data lies in the statistical manipulations and projections used to determine the required level of reduction for the attainment of standards. Basing an extensive control program on measurements obtained in one or two hours per year may lead to the imposition of unduly strict control measures. The trend of ambient measurements during the period before the target year of 1977 must be carefully watched and used to adjust control measures according to observed ambient conditions. Further, specific high measurements obviously due to adverse meteorological conditions may be considered as episode control situations and may not require the imposition of long-term transportation control strategies for their solution.

1.2.2 Emission Factors

The mobile source emission estimates utilized in this study are based upon the best currently available emission factor estimates. These emission estimates are in the process of updating and revision with both in-use and new vehicle testing programs, conducted by the Environmental Protection Agency. The applicability of the standard testing driving cycle to the driving patterns in each metropolitan area is questionable. Further, there

are many trip types making up the total vehicle miles traveled in each area; and it has not been possible on the basis of currently available data to distinguish in an air pollution emissions sense between the different driving modes used. It is highly recommended that new emission factors be utilized as they become available to recompute and redefine the severity of the mobile source generated emissions in the region. Finally, the emission factors used in the study relate speed to emissions only on the basis of the integrated driving cycle. This has prevented the accurate assessment of changes in emissions due to improvement in traffic flow characteristics in core, center city areas.

1.2.3 Cold-Start Emissions

Preliminary data have shown that the emissions generated during the first few minutes of vehicle operations represent a large and increasing portion of the total emissions during any individual vehicle trip. The implications of this fact are that to truly reduce mobile source emissions it may be necessary to address the reduction in total vehicle trips rather than merely reducing the number of vehicles miles traveled. Unfortunately, the data relating to this phenomena were not sufficiently developed to be used in the analysis presented in this study. A potential control strategy to reduce the high level of cold start emissions might be the direct control of emissions from parking structures which act as stationary sources. Again, it has not been possible to quantitatively describe the effect of this type measure on the regional air pollution problem in this report.

1.2.4 Traffic Data and Projections

Traffic data and traffic projections have not historically been collected with a view to the estimation of motor vehicle air pollution emissions. This fact has necessitated the reworking of traffic data including vehicle flows, speeds and modal mixes into the format necessary for emission calculations. Certain assumptions and potential inaccuracies have been introduced by this process. Further the use of trends and projections in vehicle growth have been prepared by various agencies and often little unanimity has been found concerning appropriate growth rates. These data

in certain cases require that a close watch be maintained both on traffic changes and ambient air quality during the period between now and full strategy implementation so that any deviations from the expected vehicle emission rates can be determined and appropriate adjustments made in the control strategy. It should be noted that stationary source emission projections also suffer from inaccuracies in the projection of industrial growth and in the application of as yet untested control technologies to control of these stationary sources.

1.2.5 Analytic Techniques Used

The key analytic calculation performed in this study is the relation between emission levels and ambient air quality. Due to the time restraints it was not possible to utilize sophisticated mathematical modeling techniques in the development of this relation between emissions and air quality. Control strategy reductions were thus based on proportional rollback techniques relating existing emissions and air quality on a proportional basis. The use of modeling is highly recommended since it will both include the effects of local meteorological and topographical features and indicate, in a way that rollback estimation cannot, the geographical extent of the regional air pollution problem. Such modeling and simulation exercises using models currently under development should be carried out during the years between now and 1977 and should be used to modify, if required, the control strategy recommended in this document.

1.2.6 Effects of Control Measures

It was generally not possible to expressly quantify the emission reduction effect of many of the control measures considered in this document. For example, the effect of the inspection and maintenance program depends strongly upon the exact test procedure used, maintenance recommendations, the quality and availability of trained mechanics and a host of other factors which were impossible to define exactly during this study. Similarly, mass transit improvements can be expected to reduce vehicle miles traveled within the region. However, the extent of this reduction is unknown and specific data concerning the economic elasticity of the various travel demands, the modal split of trips within the region, and many other factors need to be carefully evaluated before a quantitative estimate can be prepared.

It is strongly recommended that programs be instituted to provide additional data and to apply more sophisticated analytic techniques in the areas listed above. Work must begin upon the implementation of the required regional control measures; however, final implementation and enforcement should be dependent upon data collected during calendar years 1973, 1974, and even 1975. Full consideration must be given to the political, jurisdictional and social impact of all control actions. The control strategy presented in this document must be considered as an initial attempt to quantify the relationship between transportation processes and the regional air pollution problem. The further study indicated should be used to modify this baseline effort. The air pollution implications of the transportation process are very complex and a modification of this process can potentially effect significant changes in the social and economic character of the metropolitan region.

2.0 GENERAL METHODOLOGY

Transportation control measures must be defined which will reduce mobile source emissions to a level which will allow compliance with the Federal air quality standards. The technical approach is to select candidate control measures and quantify where possible the emissions reductions expected. Control strategy development includes the following tasks:

- Development of emissions and air quality estimates.
- Definition of Control Measures - Transportation control measures fall into two categories; exhaust emission reductions and reduction of vehicle miles traveled (VMT). These control measures may be both long and short-term and region-wide or area specific in extent.
- Analysis of the socioeconomic impact of strategies and the obstacles to their implementation

These subtasks are described in the following sections.

2.1 EMISSIONS AND AIR QUALITY ESTIMATES

2.1.1 Emissions Estimates

A vehicle emission estimate is the product of two factors; vehicle miles travelled (VMT) and an emission factor or rate. The techniques employed for the determination of VMT, speeds, and vehicle age distributions varied widely from city to city and descriptions of these techniques can be found in the individual city reports. The vehicle emission factors used in this study are based on measured and projected emission rates for each vehicle class considering age of vehicle, effectiveness of emission controls, average speed, and vehicle age distribution. The impact of Federal new car standards is considered in both the present and projected vehicles. The emission factor development followed the procedure developed by Kircher and Armstrong⁽¹⁾ of the EPA. A summary of the procedure is given below.

⁽¹⁾ D. S. Kircher and D. P. Armstrong, "An Interim Report on Motor Vehicle Emission Estimation," Environmental Protection Agency, October 1972.

EMISSION FACTOR CALCULATIONS

The equation for calculating emission factors is shown below:

$$e_{np} = \sum_{i=n-12}^{n+1} c_i d_i m_i s_i$$

where,

- e_{np} = emission factor in grams per vehicle mile for calendar year n and pollutant p ,
- c_i = the 1975 Federal test procedure emission rate for pollutant p (grams/mile) for the i^{th} model year, at low mileage
- d_i = the controlled vehicle pollutant p emission deterioration factor for the i^{th} model year at calendar year n ,
- m_i = the weighted annual travel of the i^{th} model year during calendar year n (The determination of this variable involves the use of the vehicle model year distribution),
- s_i = the weighted speed adjustment factor for the i^{th} model year vehicles.

c_i is based on a recent study of light duty vehicle exhaust emission rates in six cities. d_i , deterioration factor accounts for the aging or deterioration of emission control devices. m_i , weighted annual mileage is determined as follows,

$$m_i = \frac{V \times D}{\sum V \times D}$$

V = fraction of each model year vehicle in use on December 31 of year

D = average miles driven of each model year vehicle

s_i , speed adjustment factor, varies inversely with average route speed. 1975 and later model years are assumed to have a factor of one.

Emission estimates for non-vehicular sources and their projected growths were obtained from the state implementation plans.

2.1.2 Air Quality Estimates

In order to evaluate the acceptability of a transportation control measure it was necessary to compare the estimated emissions following application of that control measure with an "allowable emission rate" or goal to be achieved. This "allowable emission rate" must be extrapolated from existing air quality data.

Air quality standards to be attained are prescribed by the Federal government in terms of concentration values (parts per million, or micrograms per cubic meter) and not emission values. Therefore, some system of conversion must be employed to quantitatively assess the effect of emissions and changes in emission rates on concentration values. Several methods are currently available ranging from simple rollback proportioning through very elaborate and detailed computerized diffusion models.

The proportional rollback method assumes the existence of a linear relationship between emissions and air quality. A given percentage change in emissions produces the same percentage change in air quality. It also assumes a homogeneous distribution of emission changes and effects of emission changes over the region under consideration. No consideration is made of meteorology, topography, atmospheric residence time, pollutant half life, photochemical reactivity, or any of the many other complex variables affecting the relationship between emissions and air quality.

Modeling techniques consider some or all of the above variables were utilized when applicable. These models require great quantities of detailed input data, and extensive amounts of time and money in order to obtain results.

In selecting a technique to be used, several compromises and trade-offs must be made. Proportional rollback modeling is fast and inexpensive, and requires very little accumulation of input data. The results are easy to interpret, but due to limitations discussed above, they are not highly accurate. If extremely accurate results are desired, detailed data is complete and accessible, and if time and funds are freely available, then sophisticated computer modeling should be used. Care should be taken, however, not to attempt to use a method which requires a greater degree of input data accuracy than that which is available. Inaccurate or incomplete input data will produce inaccurate results in both sophisticated and simple models.

There are many variations of these modeling techniques which incorporate some of the advantages of each extreme. Some form of proportional "rollback" has been used in each of the metropolitan areas studied. The specific application of this technique varied considerably in order to accommodate the wide range of input data and output requirements. A sample methodology for the application of a modified proportional "rollback" to CO and oxidants is given below.

Sample Methodology for Carbon Monoxide

Because ambient concentrations of carbon monoxide at any given location appear to be highly dependent on carbon monoxide emissions in the near vicinity, it was felt that some justification existed for a modification of the proportional model. It was felt that in order to reduce ambient CO levels in, for example, a central business district (CBD), it would be more appropriate to roll back CO emissions in the CBD itself, rather than the entire air quality region. The assumption was therefore made that pollutant concentration in any given zone was directly proportional to the emission rate of that pollutant emission within that

zone. Accordingly, each city area was divided into traffic zones--about the size of the central business district (CBD) in the center of the city with increasingly larger zones towards the suburban areas. Where traffic data were already available for existing "traffic districts," the traffic zones were either the traffic districts themselves or suitable aggregations thereof. Otherwise, the traffic zones were based on rectangular grids.

An emission density/concentration ratio (e/c ratio) was assigned to each sensor, the e/c ratio being based on the total CO emission density (expressed in Kg/sq. mile/24 hrs.) for the base year within the zone in which the sensor was located, and the CO concentration value which formed the basis of the proportional rollback computations. Based on the e/c ratios so obtained, the maximum allowable emission density was derived which corresponded to the national air quality level to be achieved (i.e., 9 ppm for an eight-hour average). Maps showing the emission densities for each zone were then prepared for years 1977, etc., based on the predicted vehicular and non-vehicular emissions for those years. Vehicular emissions were based on traffic patterns predicted for those years in the absence of any transportation controls imposed in order to meet national air quality standards for CO (the "no strategy case"). Non-vehicular emissions for the years of interest were obtained from state implementation plans and state agencies, and take into account predicted growth and the predicted control strategies to be applied to those sources.

From these maps, the zones in which emissions exceeding the maximum allowable density were identified. On the assumption that the predicted emission densities from non-vehicular sources were to be taken as irreducible, the allowable emissions from motor vehicles in each zone for the year of interest were then determined. For the purposes of evaluating the effects of candidate transportation controls, the maximum allowable emission density for the year 1977 was expressed as a percentage reduction from the 1977 "no strategy" emission density. However, as each control measure was developed, emissions were recomputed, using the revised VMT's and speeds resulting from the application of the control measures.

Discussion of Sample Methodology for Carbon Monoxide

The applications and the limitations of the conventional proportional rollback method have been well documented and reviewed⁽²⁾ and need not be discussed further here. The technique used in the present study was an extension of the conventional rollback technique to the extent that it was assumed first, that the constant of proportionality between emissions and concentration may be derived from emissions emanating from the relatively small area around the sensor (the traffic zone), and second, that this constant of proportionality (the emission/concentration ratio) could be applied to determine pollutant concentrations in other zones of comparable area on the basis of the pollutant emissions in those zones.

Some justification of the first assumption can be found, for example, in recent work of Hanna⁽³⁾ and Gifford⁽⁴⁾ who demonstrate the dominance of urban pollution patterns by the distribution of the local area sources. The success of their urban diffusion model, in which concentration is simply directly proportional to the area source strength and inversely proportional to wind speed, is attributed largely to the relatively uniform distribution of emission within an urban area and the rate at which the effect of an area source upon a given receptor decreases with distance. In the proportional model, meteorological effects, such as wind speed, are assumed to be duplicated over one-year periods. The validity of the second assumption depends, in large part, upon the extent to which diffusion and transport parameters are uniform from zone to zone--a factor which could not be investigated because of the constraints of the program. Thus, it was felt that, in the absence of a more sophisticated technique, the use of this extension to the proportional model was

(2) Noel de Nevers, "Rollback Modelling, Basic and Modified," Draft Document, EPA, Durham, N. C. August 1972.

(3) Hanna, S. R., "A Simple Method of Calculating Dispersion from Urban Area Sources," J. APCA 21, 774-777 (December 1971)

(4) Gifford, F. A., "Applications of a Simple Urban Pollution Model," (paper presented at the Conference on Urban Environment and Second Conference on Biometeorology of the Amer. Meteor. Soc., October 31 - November 2, 1972, Philadelphia, Pa.)

justified first, to obtain some assessment as to whether the existing sensors were located in the hot-spots, and second, to obtain some assurance that transportation strategies intended to reduce emission densities in one zone (to the level required to meet ambient standards) did not increase emission densities to unacceptable levels in adjacent zones. In some cities it was found that the sensors were, in fact, in the "hot spot" zones and also that the recommended transportation controls did not increase emissions in adjacent areas to unacceptable levels. Thus the final roll-backs were confined to the zones with a sensor within their boundaries and the extensions of the techniques to other non-sensor zones did not, therefore, play a primary role in the final computations.

As might be expected, where an urban area had several sensors, the emission concentration ratios were widely different and this served to underline the fundamental limitations of the technique employed. An implicit assumption in the technique employed was that the air quality in a traffic zone could be fairly represented by one concentration level and that this level depended only upon the average emission density within that zone. The two major factors mitigating against this assumption are:

- a) Emission densities are not uniform across even a small traffic zone.
- b) Concentration levels are not uniform across the traffic zone partly because of the lack of uniformity of emission density and partly because the point surface concentrations are affected by micrometeorology and microtopography as well as emission density.

Considerable judgment had to be used, therefore, both in the derivation of e/c ratios and in their subsequent use. In heavily trafficked downtown areas the variation was judged not to be too great, so that the single recorded concentration might reasonably be expected to be representative of the zone's air quality and emission density. However, in suburban zones having overall low traffic densities, sensors were often found to be placed at very localized hot spots, such as a traffic circle, so that the recorded concentration levels were neither representative of the overall air quality nor of the overall emission density in the zone.

Accordingly, e/c ratios were generally derived from sensors in the central areas of the cities and applied to suburban areas for the prediction of 1977 concentration levels. This procedure gave air quality levels which were generally representative of the suburban zone. However, it must be realized that control strategies based on this procedure, while they may insure that the overall air quality in a suburban zone will not exceed ambient standards, do not preclude the occurrence of higher concentrations in very localized hot spots such as might occur in the immediate vicinity of a major traffic intersection.

Seasonal and Diurnal Variations

The carbon monoxide concentration level chosen as the basis for the base year e/c ratio in any zone was, in all cases, the highest valid eight-hour average observed during the base year. The one-hour average either never exceeded the standard or was very much closer to the standard than the eight-hour average, so that controls required to meet the eight-hour standard would also result in the one-hour standard being met. Motor vehicle emissions over 24 hours, 12 hours and max eight-hour periods were compared with sensor readings and the most appropriate period of time selected on which to base calculations of emission density. Although seasonal variations in readings were noted, traffic data was not available on a seasonal basis, so that vehicle emissions were based on annual average work day traffic data.

Background Concentrations

Background concentration levels of CO were not taken into account. Where a zone was located near a large point source, simple "worst case" diffusion calculations were performed to assess the effect of the point source on the zone. In all cases, it was found that this contribution was negligible. Where a zone actually contained a large point source, its emissions were found to be much greater than automotive emissions within the zone and any problem in that zone was regarded as due entirely to the stationary source.

Sample Methodology and Discussion for Oxidants

The technique employed for oxidants was basically the same as has just been described for CO with the major difference that only one, very much larger area was used as the basis for the proportional rollback. Because of the length of time required for the formation of oxidants from hydrocarbon emissions, the relatively small areas used as the basis for CO could not be justified. The actual area used in each city was largely a matter of judgment and, in general, was about the size of the metropolitan area. The reductions in hydrocarbon emissions necessary to achieve oxidant ambient standards were obtained from Appendix J, Federal Register of August 14, 1971.

In some cities the use of the larger area presented two problems. First, where there was more than one valid oxidant sensor within the area, the question arose as to which gave readings best representative of the area's air quality, and usually the sensor giving the highest reading was selected. Second, it was found for some cities that the amount of rollback required for vehicle hydrocarbon emissions was significantly sensitive to the size of the area selected. Generally, it was found that vehicle emissions peaked sharply in the CBD and tapered off towards suburban areas, while non-vehicular emissions were relatively evenly distributed over the metropolitan area. Thus, if a relatively small rollback area (encompassing the CBD) was selected, vehicle emissions constituted the major portion of the total emissions. On the other hand, if an entire metropolitan area was selected, non-vehicular emissions could constitute more than half the total emissions. Since the predicted 1977 non-vehicular emissions were considered to be irreducible, the total required rollback from the "no-transportation strategy case" had to be obtained from reductions in vehicular emissions; and where the total emission rollback was required to be about 50 percent or more, the vehicular emission rollback became very sensitive to the ratio of the vehicular emissions to total emissions. For example, for the case of a required total emission rollback of 50 percent, if non-vehicular emissions were 20 percent of total emissions, a rollback of about 62 percent of vehicular emissions would be required; while if non-vehicular emissions were 40 percent of total emissions, a rollback of about 83 percent in vehicular emissions would be required.

2.2 CONTROL MEASURES CONSIDERED

Vehicle emissions control measures fall into two categories - direct exhaust emission controls, and indirect control through the reduction of vehicle miles of travel (VMT) or vehicle use. The major types of control measures in these categories are discussed below. The specific elements of these control measures applicable to each city are given in Sections 3.1-3.14 of this report.

2.2.1 Exhaust Emission Controls

Four major types of exhaust emission control measures have been considered as follows:

- Federal emissions control requirements for new cars.
- Inspection/Maintenance Programs (I/M).
- Retrofit of Light Duty Vehicles (LDV).
- Gaseous fuels conversion.

The main advantage of this group of control measures is that their impact is region-wide. This is important because physical and meteorological conditions cause all emission areas to contribute to the formation of critical concentration zones. An area-wide control measure also helps maintain the air quality in areas not currently exceeding the standards and provides for some control in areas which may exceed the standards but are not currently monitored.

Each of the four types of exhaust emission controls are discussed briefly below. They are discussed in detail in the EPA document "Control Strategies for In-Use Vehicles".

- Federal Emissions Control Requirements For New Cars.

The Federal 1975 standards for new cars are assumed to be met. Though these controls are highly effective in reducing emissions the turnover rate by 1977 will not be sufficient to meet the required reductions in most of the fourteen metropolitan areas studied.

- Inspection/Maintenance (I/M).

The many varieties of programs and their benefits are discussed in detail in "Control Strategies for In-Use Vehicles". An "Inspection/Maintenance" program is defined as a means to reduce emissions from in-use vehicles through identifying those vehicles that need emission control related maintenance and requiring that such maintenance be performed. The reason that such a program can achieve additional reductions is that current in-use emission control devices deteriorate or their effectiveness deteriorates due to other automotive parameters such as a poorly tuned engine. Therefore the purpose of an I/M program is to maintain exhaust emissions from in-use vehicles as close to the standards of the new vehicle as possible and thereby gain the maximum benefit from emission control technology.

- Retrofit of Light Duty Vehicles (LDV).

The majority of retrofit devices are designed for installation in pre-controlled or pre-1968 light duty vehicles although some can be effective on other vehicles. There are two prime considerations for selecting retrofit devices; which pollutant do they most effectively reduce and what segment of the automotive population is affected. Although the retrofit devices are very effective in reducing emissions from these vehicles the added reduction in total emissions by 1977 is generally less than 10 percent of the total emissions. There are however, two advantages to this control measure, its impact is region-wide, and it is directed at the worst polluters.

- Gaseous Fuel Conversion.

Recommendations for the use of gaseous fuel conversion is limited to metropolitan areas where large, centrally located fleet travel represents a significant portion of the total VMT. It is further restricted by the limited supply of such fuels in many areas.

2.2.2 VTM Reduction

Long-term VMT reduction measures such as mass transportation systems not currently planned for completion by 1976 will have little impact on meeting the air quality standards by 1977; however, their impact beyond 1980 could be significant.

The short-term reduction measures consist of methods to encourage use of existing and immediately planned public transportation and methods to directly or indirectly reduce actual trips or VMT. Samples of these groups of short-term measures are listed below:

Methods to Encourage Use of Public Transportation

Improved Bus Service
Peripheral Parking
Park-And-Ride Systems
Exclusive Bus Lanes
Subsidized Transit Systems

Methods to Reduce Actual Trips or VMT

Pollution Tax
Wheel Tax
Gas Rationing
Auto-Free Zones
Parking Limitations
Carpooling
Improved Traffic Flow

The majority of the encouragement methods will not achieve a significant VMT reduction without the imposition of direct vehicle restraints.

2.3 OBSTACLES TO IMPLEMENTATION

Each of the major categories of air pollution control measures has a varying potential for effective implementation in the study areas. A mail panel survey⁽¹⁾ of seven Metropolitan areas, for example, (see Appendix A) indicated a greater awareness of a nationwide air pollution problem than a local air pollution problem. Acceptability responses of various control measures were conditioned by the financial cost to individual motorists, the degree to which motorists might be limited in the use of their automobiles, and the inconvenience of the control measures. Long-term measures, such as public transportation improvements, generally are acceptable and desirable even though reducing air pollution may not be

1 - See Appendix A for complete discussion of the mail panel survey.

the primary reason for implementing this measure. On other specific actions which would be required as segments of other measures, the panel survey was inconclusive. For example, a tax on all day parking, and any restriction on non-essential auto travel had approximately as many respondents for as against these measure.

The primary control measures reducing air pollution--that of fitting control devices to cars and mandatory inspections to assure their continued effectiveness--seem to be the most acceptable.

2.3.1 New Car Standards

The Federal new car pollution standards seem to have been accepted and anticipated with little concern for increased costs for new cars so equipped.

2.3.2 Vehicle Inspection and Maintenance

Two factors must be designed into the inspection process and specifically included in expanded enabling legislation. The inspection charges must be reasonable--the mail panel survey favored a fee of less than \$5 annually--and it must be convenient. During various discussions in the cities, some opposition was encountered to having an inspection program imposed on a statewide basis to solve a metropolitan problem.

2.3.3 Retrofit of Pre-1968 Cars

The ease of adopting legislation to require the installation of retrofit devices on cars built before 1968 will be directly related to the cost of installing their devices. While the majority of the panel respondents favored this action if it cost under \$50, few felt that it would be justified at a cost of \$200 per car.

Costs for retrofitting pre-1968 motor vehicles in the \$200 range could be equal to or in excess of the actual market value of the car. To the extent that this level of cost might eliminate the second car in a

family, it would be beneficial to reducing air pollution from light duty vehicles. Although the ownership of older cars by level of income is not known, this requirement could impose a serious financial burden on lower income families.

2.3.4 Vehicle Use Reduction

The predominant opposition to vehicle restraints suggested by the mail survey indicates restraints are not measures readily acceptable by the public. Suggested measures included such constraints as a very high (\$500) registration fee, gasoline rationing, or tolls on exit ramps of freeways. Inherent to constraining the use of the automobile is the mandatory provision of making available some alternative mode of transportation.

The more severe restrictions on the use of motor vehicles could be recommended. However, on the basis of travel forecasts made available for this study and limited air monitoring data, these measures could become controversial. They will have a major impact on the economic and social character of the region. It is recommended that several actions be undertaken to increase the ability to quantify the effectiveness of these control measures before actually implementing them.

A network of air monitoring stations must be established throughout the region to (1) obtain comprehensive air data for evaluation; (2) determine the actual impact of the more palatable inspection and retrofit controls; and (3) to support the need for the more severe traffic restrictive controls. Traffic forecasts measuring effects of alternative approaches to emission factors, and refinement of modal use and sensitivity analysis also should be undertaken.

Based on these continuing studies, a greater refinement in the air pollution analysis can be undertaken, pollution criteria reevaluated, and more accurate quantification of solutions undertaken to support a greater reliance on the appropriateness of the required control measures.

Pending adequate basic data for imposing control measures requiring massive outlays of public funds, economically impacting major areas of the city, or requiring the resident to substantially modify his travel habits, the less severe measures which can be initiated include the following.

2.3.5 Car Pooling

Encouraging car pooling can result in some reduction of air pollution without major social or economic impacts. A small percentage of respondents to the survey indicated that they now participate in car pools, the majority indicated an interest in them, but only about 10% indicated that, if necessary, it would be easy to get into one.

2.3.6 Peripheral Parking, Exclusive Bus Lanes

The two most acceptable motor vehicle restraints indicated by survey respondents were creating exclusive bus lanes and prohibiting traffic or parking in the CBD. Any prohibition of traffic or parking in the CBD, however, will require an effective program of peripheral parking and transit within the CBD. Increased effectiveness of the present "park-and-ride" programs will be necessary. Both of these control measures assumes an improved bus transportation.

2.3.7 Improved Bus Transportation

The improvement of the bus service in most metropolitan areas is currently under way. The air pollution control measures have assumed that these improvements will continue as planned and may include such service improvements as: express bus service, exclusive bus lanes, peripheral parking, "PRT" personnel rapid transit, regional bus network, and greater improved transit service.

Refinement of presently used mechanisms for furnishing bus service outside the city limits, or additional legislation, will be necessary.

Although major economic investments will be required, they have already been justified as a cost of a balanced transportation system.

2.3.8 Long-Term Measures

Limited planning programs have already been established and work is presently under way to achieve the coordination of land use planning and transportation-related environmental factors.

These long-term approaches to solving urban problems are generally accepted by both the citizens surveyed and the public officials contacted. Although not initially justified for the reduction of air pollution, they furnish one of the more acceptable long-term measures to accomplish this goal.

3.0 SUMMARY AND CONCLUSIONS FOR FOURTEEN METROPOLITAN AREAS

This section presents brief summaries of the air pollution problems encountered and the concomitant transportation strategies recommended, for each of the fourteen urban areas studied. Some primary characteristics of the fourteen cities studied are presented in Figure 3.1, together with major parameters of their pollution problem. While this matrix will assist in identifying those cities having characteristics and air pollution problem parameters similar to the city of interest it should be emphasized that the strategies presented are very specific to the city for which they were developed and there is not necessarily a strong relationship between the parameters presented and the strategies recommended for each city.

	Population	> 1 x 10 ⁶	> .5 x 10 ⁶	0 - .5 x 10 ⁶	Altitude	> 4000 feet	< 4000 feet	Pollutant Problem	CO	Oxidants	Percentage of Baseline Emissions by Source	Light-Duty Vehicle (LDV)	Heavy-Duty Vehicle (HDV)	Other Vehicles	Non-Vehicular	HC	LDV	HDV	Other	Non-Vehicular
Baltimore		X					X		X	X		67	15	<1	18		50	14	<1	36
Boston		X					X		X	X		79	16	1	4		34	9	<1	57
Dayton				X			X			X							50	9	<1	41
Denver			X			X			X	X		90	8	<1	2		59	9	<1	34
Houston/Galveston		X					X			X							18	3	1	78
Los Angeles		X					X		X	X		85	12	3	1		72	10	2	16
New York		X					X		X	X		70	22	<1	8		48	21	<1	31
Philadelphia		X					X		X			77	9	<1	14					
Phoenix/Tucson			X				X		X	X		76	18	2	4		52	21	4	23
Pittsburgh		X					X		X	X		83	9	<1	8		71	7	<1	22
St. Paul/Minneapolis		X					X		X			88	11	<1	1		58	11	1	31
Salt Lake City			X			X			X			96	2	<1	2		70	2	<1	20
Seattle		X					X		X			90	8	1	2		63	12	<1	25
Spokane				X			X		X			86	12	<1	2		61	10	1	29

Figure 3.1. METROPOLITAN AREA CHARACTERISTICS

3.1 SUMMARY AND CONCLUSIONS - BALTIMORE, MARYLAND

3.1.1 Air Quality and Emissions Reductions

The existing air quality levels in Baltimore are monitored by two networks of sensors, one of which provided CO data at a number of sites throughout the areas, the other providing oxidant data for the center city only. One network operates stations throughout the urban area and provided the carbon monoxide data used herein; after extensive validation, data were available from seven sites. The maximum eight-hour average levels range from 20.6 ppm at a site in the center city area (though not in the CBD) to 9.9 and 7.0 ppm at outlying suburban sites. Using the empirical relation between air quality and emissions developed from these sites, it is estimated that the maximum eight-hour CO level in the densest portion of the city is about 30 ppm.

The only oxidant data available from these stations are from phenolphthalein grab samples, and in the past has generally indicated minimal oxidant problem. However, reference method data from the new state network's center city have very recently become available; and data from the summer of 1972 indicate a much more severe oxidant problem, with a maximum one-hour level of 0.21 ppm. Thus, these latter data were used for the evaluation here.

In the case of carbon monoxide, an empirical relation was developed between air quality at a site and the emission density in its vicinity. This relation was then used in conjunction with projected 1977 emission densities to predict the 1977 air quality in three separate analysis areas. The results, which included the reduction through the Federal Motor Vehicle Pollution Control Program (FMVPCP), were compared with the national air quality standards to determine any further reductions required. In the case of oxidants, the standard relationship derived by EPA enabled the direct determination of the total hydrocarbon reductions required (69 percent) and any additional over that provided by the federal programs.

With this methodology, it was determined that the oxidant standard will not be met in 1977. The one-hour carbon monoxide standard, which is only slightly exceeded at present, will clearly be met in 1977. The eight-hour CO standard will be met in the Urban Fringe and Suburban analysis areas but will not be met in the Central Area in 1977 without further transportation control efforts.

The oxidant levels will require a reduction in regional total hydrocarbon emissions of around 40 percent of the already reduced 1977 level, which requires a 56 percent reduction in motor vehicle emissions. This is based on an inventory of emissions in the 6-9 a.m. period; since the problem is severe, this further refinement was felt desirable. Meeting the eight-hour CO standard in the 11-square-mile Central Area of the region will require a 36.8 percent reduction in the motor vehicle portion of the emissions. Table B-1.1 presents a quantitative summary of these expected emission levels and required further reductions, with 1970 emissions included for comparison.

These conclusions, and the methodology by which they were developed, represent GCA Technology Division's best assessment of the problem; neither the methodology nor the conclusions have yet been accepted by the Air Quality Task Force, although the Maryland BAQC representatives have recommended that they be so accepted. This is, no doubt, partially due to the extreme nature of the problem as developed, particularly in the case of hydrocarbons.

3.1.2 Control Strategy

Despite major implementation obstacles associated with some of the candidate strategies, the severity of the problem, particularly the oxidant-hydrocarbon problem, requires the choice of all the most effective possibilities, including a retrofit program with an associated inspection and maintenance program, and the total subsidy of transit fares. The maximum possible reduction of emissions from light-duty vehicles is not completely sufficient, so a program of evaporative and crankcase control device retrofit for heavy-duty vehicles is necessary. Specifically, the following are recommended:

Table Bal.1.1. SUMMARY OF EXPECTED 1977 EMISSION LEVELS

	6-9 a.m. HYDROCARBONS (kg/day)	CARBON MONOXIDE (kg/mi ² /day)		
		<u>CENTRAL</u>	<u>URBAN FRINGE</u>	<u>SUBURBS</u>
<u>1970 Total</u>	58,850	10,281	3,787	780
<u>1977:</u>				
Light-duty vehicles	11,770	2,824	1,050	235
Heavy-duty vehicles	9,600	1,793	666	149
Other*	<u>8,990</u>	<u>251</u>	<u>90</u>	<u>145</u>
Total	30,360	4,868	1,806	529
<u>AQ Std. Equivalent</u>	18,244	3,078	3,078	3,078
<u>Further Reduction Required</u>	12,116	1,790	0	0

* Stationary Sources and non-gasoline vehicles

1. Traffic flow improvements
2. Bus transit service improvements
3. Total subsidy of bus transit operations
4. Mandatory retrofit of uncontrolled vehicles:
 - a. Catalytic converters on pre-1975 light-duty vehicles
 - b. Crankcase and evaporative controls on pre-1973 heavy-duty vehicles
5. Annual inspection and mandatory maintenance

The detailed reductions produced and the calculation of their total effect are shown in the following Table Bal.2. Note that the order of their presentation is dictated by the needs of the calculations, and not by preference for the various component strategies.

Table Bal.2. RECOMMENDED CONTROL STRATEGIES AND THEIR EFFECTS

Control Action	Effect	Hydrocarbon Emissions (kg/day)		Carbon Monoxide-Central Area (kg/mi ² /day)	
		6-9 a.m. peak Emissions Total	Further Reduction	Emission Density	Further Reduction
1977 Expected		30,360	12,116	4,868	1,790
Traffic flow im- provements to increase speed	Emissions de- crease equiva- lent to 10% VMT reduction	- 2,162 28,198	- 2,162 9,954	- 467 4,401	- 467 1,323
Total subsidy of transit fares with associated service improve- ments and parking restraints	15% decrease in VMT	- 3,243 24,955	- 3,243 6,711	- 700 3,701	- 700 623
Inspection and maintenance pro- gram	Effective emission reduction: HC-4.01% and CO-3.19%*	- 650 24,305	- 650 6,061	- 112 3,589	- 112 511
Control Device Retrofit:					
a) Catalytic con- verters on pre- 1975 light-duty vehicles	Effective emission reduction: HC-23.33% and CO-27.33%	- 3,783 20,522	- 3,783 2,278	- 957 2,632	- 957 0
b) Evaporative and crankcase control on pre- 1973 heavy-duty gasoline vehicles	Reduction of hydro- carbon emissions by 6.8% of heavy-duty vehicle contribution	- 2,612 17,910	- 2,612 0	- - - No CO Effect - -	- - -

* In both cases, % reductions apply to the 75% of motor vehicle emissions remaining after VMT reductions.

3.2 SUMMARY AND CONCLUSIONS-BOSTON, MASSACHUSETTS

3.2.1 Air Quality and Emissions

Carbon Monoxide Air Quality and Emissions

The eight-hour average CO air quality will not be achieved by 1977 in several zones in the inner city of Boston with the CO emission reductions obtained from the Federal Motor Vehicle Emissions Control Program. Three zones (Kenmore Square, Haymarket Square-Government Center and Science Park) will exceed the standard by a substantial amount, while two others (the East Boston Area by the Sumner-Callahan Tunnel and the Washington Street-Albany Street Area) will exceed it slightly. Tables Bos.1, Bos.2, and Bos.3 summarize the emissions and air quality in the three most critical zones with and without the application of the recommended control strategies. The other two zones will easily attain the air quality when any of the recommended transportation controls are applied.

Oxidant Air Quality and Hydrocarbon Emissions

The oxidant problem in Metropolitan Boston is regional and assumed to be uniform within the Route 128 area. A 25 percent reduction by 1977 in hydrocarbon emissions will be needed in addition to that which is attained by the Federal Motor Vehicle Emissions Control Program (FMVECP) and the reduction of the stationary sources. Table Bos.4 summarizes the emissions and air quality in the area within Route 128 with and without the application of the recommended control strategies.

3.2.2 Control Strategies

The following transportation control strategies are recommended for implementation within the Route 128 boundary and their projected impact over the years is shown in Figures Bos.1 and Bos.2.

- a. A Source Oriented Control Strategy consisting of Inspection-Maintenance and Retrofit estimated to reduce emissions as summarized in Table Bos.5.
- b. A Transportation Oriented Control Strategy consisting of a CBD Parking Management, Peripheral Parking Facilities, moderate Transit Improvements, Road Pricing and Traffic Flow Improvements. These are estimated to reduce emissions in the inner city and throughout the region by the percent shown in Table Bos.5.

TABLE BOS.1

CARBON MONOXIDE EMISSIONS (KG/DAY) AND CONCENTRATION (PPM)
KENMORE SQ. WITH AND WITHOUT CONTROL STRATEGIES

	Present 1970	1977 without strategy	1977 with strategy
Vehicular Emissions	13,130	7,164	3,790
Non-Vehicular Emissions	45	54	54
Total Emissions	13,175	7,218	3,844
CO Level (8-hour Average)	22.4	12.3	6.5
	Without Strategies		
	1978	1979	1981
Vehicular Emissions	5,917	4,852	3,468
Non-Vehicular Emissions	56	58	63
Total Emissions	5,973	4,910	3,531
CO Level (8-hour Average)	10.1	8.3	6.0

Area = 0.471 sq. mi.

TABLE BOS.2

CARBON MONOXIDE EMISSIONS (KG/DAY) AND CONCENTRATION (PPM)
AT HAYMARKET SQ. WITH AND WITHOUT CONTROL STRATEGIES

	Present 1970	1977 without strategy	1977 with strategy	1978 without strategy	1979
Vehicular Emissions	12,119	7,837	4,195	6,472	5,306
Non-Vehicular Emissions	45	54	54	55	57
Total Emissions	12,164	7,891	4,249	6,527	5,363
CO Level (8-hour Average)	20.7	13.4	7.2	11.1	9.1

Area = 0.471 sq. mi.

TABLE BOS.3

CARBON MONOXIDE EMISSIONS (KG/DAY) AND CONCENTRATION (PPM)
AT SCIENCE PARK WITH AND WITHOUT CONTROL STRATEGIES

	Present 1970	1977 without strategy	1977 with strategy	1978 without strategy	1979
Vehicular Emissions	14,148	8,658	4,645	7,238	6,027
Non-Vehicular Emissions	45	54	54	55	57
Total Emissions	14,193	8,712	4,699	7,293	6,084
CO Level (8-hour Average)	24.2	14.8	8.0	12.4	10.4

Area = 0.471 sq. mi.

TABLE BOS.4

HYDROCARBON EMISSIONS (KG/DAY) AND OXIDANT LEVELS (PPM)
WITHIN RT. 128 REGION WITH AND WITHOUT CONTROL STRATEGIES

	Present 1972	1977 without strategy	1977 with strategy	1978 without strategy	1979
Vehicular Emissions	131,555	72,101	47,800	61,000	52,500
Non-Vehicular Emissions	170,002	51,000	51,000	52,500	54,000
Total Emissions	301,557	123,101	98,830	113,500	106,500
Oxidant Level (1-hour Average)	.20	.10	.074	.089	.081

Area = 243 sq. mi.

TABLE BOS.5

EMISSION REDUCTIONS WITH RECOMMENDED CONTROL STRATEGIES

Program Element	Program Strategy	Percent Emission Reduction			
		Inner City		Region	
		HC	CO	HC	CO
Source Control	Inspection and Maintenance	10.4	8.7	10.4	8.7
	Retrofit	33.2	43.5	33.2	43.5
Transportation Oriented	CBD Parking Management, Peripheral Parking Facilities, Mass Transit Improvements, Road Pricing	11.1	11.1	3.9	3.9
	Traffic Flow Improvements	1.5	1.5	.3	.3
	TOTAL	56.2	64.8	47.8	56.4

3.3 SUMMARY AND CONCLUSIONS-DAYTON, OHIO

3.3.1 Air Quality

The second highest measurement of oxidant concentration during 1971 was 343 micrograms per cubic meter, one hour reading. It was measured at the sole monitor operating at that time (just off Dixie Drive, approximately five miles north of town). The national primary standard of 160 micrograms per cubic meter, one hour reading, must be achieved by July 1977. Carbon monoxide measurements indicate that no problem should exist with carbon monoxide ambient air levels by July 1977.

Serious doubt exists about the validity of the data used to determine the air quality for the Dayton area. Reasons for this doubt are based on the erratic nature of peak value (732 micrograms per cubic meter) obtained on only one day in well over a year of monitoring, and upon the fact that neither this value nor any value close to it has been repeated since August 1971. During the equivalent period of 1972, no value of the same order of magnitude was obtained. Perhaps the most important factor in questioning the validity of the 1971 summer data is the location of the monitor in relation to abnormal traffic flow patterns during that time. At the time when the high readings were obtained, a temporary interchange was located at the interstate highway approximately one mile east of the monitor. Traffic was diverted to a road upwind of the monitor across to Dixie highway, located to the west of the monitor approximately 200 to 300 yards. It might be noted that during this time when the high oxidant readings were obtained, the carbon monoxide monitor in the CBD did not have a correspondingly high peak. This would indicate that the emissions in the CBD were not in proportion to the unusually high value measured at the monitor located 4 to 5 miles north of town. In addition, the monitor is located in a parking lot used by the school district for parking school buses. Although these buses should not normally create a problem with photochemical oxidants due to the lag time in oxidant formation after emission of hydrocarbons and oxides of nitrogen, the buses could have been involved in the especially high reading that was recorded on August 30 due to the excessive NO_2 interference which may not have been accounted for by usual statistical adjustment procedures.

It should be noted that the temporary interchange has since been closed and the interstate highway opened to traffic. During the summer of 1972 no value approached the single value measured on August 30, 1971, of 372 micrograms per cubic meter, and in fact no value approached that level again after August 30, 1971. The second highest reading was measured the hour after the highest reading on August 30, and that value was 343 micrograms per cubic meter. The next highest value measured was on August 30, 1971 (314 micrograms per cubic meter). The highest value measured during the summer months of 1972 and in fact the highest value measured since September of 1971 was 225 micrograms per cubic meter, on August 31, 1972. This was the only value to exceed 200 micrograms per cubic meter since September 1971. This indicates that a significant reduction in oxidant levels in the vicinity of the monitor has occurred. It is not felt that meteorological changes alone should cause an overall shift in values of this magnitude and consistency.

The most obvious reason for this reduction would be the improved traffic flow patterns around the monitor. It seems that the high values measured in August 1971 were due to the unusual traffic conditions in this area, the school bus situation, or some other unexplained localized phenomena.

3.3.2 Emission Reduction Required

A reduction of 58 percent in hydrocarbon emissions is estimated to be needed to achieve the oxidant National Ambient Air Quality Standard, assuming the air quality data to be accurate and representative.

Table Day.1 shows the stationary, mobile, and total hydrocarbon emissions for 1971, 1977 with only federal emission controls applied, and 1977 as required to meet the National Ambient Air Quality Standard (58 percent reduction in total emissions). Comparison of the two 1977 columns indicates that an additional 27.2 percent reduction in mobile emissions will be required to achieve the necessary 16.2 percent required reduction in total emissions.

TABLE DAY.1

24-HOUR HYDROCARBON EMISSIONS FOR
MONTGOMERY AND GREENE COUNTIES (kg/day)

	1971	1977 (Federal)	1978 (Federal)	1977 (Standard)
Stationary	61,224	29,902	31,009	29,902
Mobile*	86,693	44,251	38,655	32,223
Total	147,917	74,153	69,664	62,125

*Based on average speed of 28.0 mph for 1971 and 29.1 mph for 1977, 78.

Based upon the preceding information, it is not possible to unqualifiedly recommend a control strategy for the Dayton area. It, however, would be in the best interest of the residents of the Dayton area for efforts to be made to reduce vehicular contributed pollution in order to further improve air quality. Special effort should be made to increase use of the mass transit system. Use of the private automobile in the CBD should be discouraged; and effort to insure proper operation of these vehicles should be made, such as a periodic inspection and/or maintenance program. In addition, an adequate air quality monitoring system should be instituted and maintained in order to measure and provide updated projections of required emission reductions. As an interim measure to insure compliance, an episode control strategy could be implemented. It should be noted that if the air quality data is correct, projections indicate that the National Ambient Air Quality Standards would only be violated twice annually at the worst (once is permissible).

3.3.3 Proposed Control Strategy

In consideration of the emission reduction potential and obstacles to implementation of the control measures considered, the following control strategy is proposed.

- Phase 1 - Problem Evaluation and Planning

In view of the limited air quality and emissions data, a comprehensive program for the expansion and review of air quality monitoring network and stationary source emissions data should be completed no later than October 1974. During this period the Episode plan described below should be fully developed and ready for implementation by Summer 1975 if necessary. Also during this period the requirements and regional extent of an Inspection/Maintenance Program most effective for the Dayton region must be defined and any preliminary testing performed.

- Phase 2 - Control Measure Implementation

By June 1975 the following control measures should be fully implemented in order to achieve maximum emission reduction potential by July 1977.

1. Inspection/Maintenance - a loaded emission test of the Key Mode type with mandatory annual inspection.
2. Transit and Traffic Improvements as currently planned.
3. An Episode Control Plan as described below.

- Episode Controls

An episode control plan is recommended for control of photochemical oxidant pollution in the Dayton region. While this type of strategy is not generally useful in providing for the attainment of National Ambient Air Quality Standards, certain specific features of the Dayton problem appear to indicate the usefulness of this strategy.

1. Based on monitoring data extending from August 1971 through September 1972, the air quality standards appear to be exceeded on less than 10 days per year.
2. The highest photochemical oxidant measurements occur during period of general atmospheric stagnation. These stagnation

periods are currently being forecasted and implementation of episode controls would not have to wait until air quality standards were actually exceeded.

3. The region is small enough, in terms of physical site and population, to permit significant diversion to non-polluting transit on a short-term basis.

It is therefore recommended that an episode control plan be adopted for the Dayton region which incorporates the following features. Detailed elaboration of this plan should be conducted by State and local officials and reported to EPA as a part of the second semi-annual report. The plan should:

1. Provide for plan activation based on a forecast of adverse meteorological conditions and deteriorating air quality (i.e. $120 \mu\text{g}/\text{m}^3$ oxidant).
2. Closing of all nonessential operations, especially those which generate large numbers of auto trips such as shopping centers, theaters, etc.
3. Mobilization of available bus fleets (school buses, national guard vehicles) to provide essential transportation.
4. Strictly enforced limitation of private auto use on major arteries in the two county area surrounding Dayton.

The episode control strategy should provide the degree of reduction in hydrocarbon emissions required to prevent formation of levels of photochemical oxidants in quantities exceeding air quality standards. It is estimated that an episode along the lines described above will reduce mobile source hydrocarbon emissions by 30 to 40 percent. This is equivalent to a 20 percent overall reduction in hydrocarbon emissions and should allow attainment of air quality standards by 1977.

3.4 SUMMARY AND CONCLUSIONS-DENVER, COLORADO

3.4.1 Air Quality and Emission Reduction

The physical and climatic characteristics of the Denver metropolitan area impose a finite limitation on the allowable emission density for the area if ambient air quality standards are to be met. Mobile source emissions are responsible for 97 percent of the total carbon monoxide emissions and 70 percent of the hydrocarbon emissions in the metropolitan Denver area. Superimposed on this physical environment is a high vehicle population growth rate (5.2 percent/year) and the highest per capita automobile ownership in the nation. The combined impact of these physical and social characteristics is to partially offset the expected benefits from the incursion of controlled automobiles into the vehicle population.

The 1971 CAMP station air quality data show a 64 percent reduction in carbon monoxide emissions required to meet the Federal eight-hour standard. The hydrocarbon emissions must be reduced by 32 percent in order to bring the peak-hour oxidant values within Federal requirements.

The emission estimates and the transportation data indicate the source of the pollutant is strongest in the center of the city. However, the outer parts of the metropolitan area contribute substantially; therefore, any program designed to reduce extreme pollution levels should not be limited to the reduction of maximum emissions area, but should include some plan for area-wide reductions. It should also be noted that although the CAMP station data support the conclusions that areas of high vehicle miles traveled (VMT) and therefore high emissions are areas of high pollutant concentration, the meteorological and physical factors documented by Riehl and Herkhof⁽¹⁾ strongly suggest that other high concentration areas may well exist which are not currently monitored.

(1) Herbert Riehl and Dirk Herkhof, "Weather Factors in Denver Air Pollution," August 1970.

3.4.2 Control Strategy

The analyses of the control measures considered most feasible for implementation by 1977 show that no one control measure will be sufficient to meet the required reduction for carbon monoxide. The reductions achievable by several combinations of control measures are shown in Tables Den.1 and Den.2. The strategies considered are as follows:

- Strategy 1 - Inspection/Maintenance, Lead Idle Air Fuel Ratio/Vacuum Spark Advance Disconnect (I&M, LIA/VSAD)

This strategy is totally exhaust control oriented. It consists of either key mode or idle inspection and maintenance with twice yearly inspection, LIA?VSAD retrofit for pre-1968 light-duty vehicles.

- Strategy 2 - Inspection/Maintenance, Lead Idle Air Fuel Ratio/Ignition Timing Modification (I&M, LIA/ITM)

Inspection/Maintenance as above with LIA/ITM retrofit for pre-1968 vehicles. The primary difference between Strategy 1 and Strategy 2 is the greater impact on CO of the Ignition Timing Modifications.

- Strategy 3 - VMT Reductions

This strategy does not include an exhaust controls with the exception of Federal new car controls. The maximum reduction is achieved in the core area. The suggested measures are (1) regional bus network improvements, (2) peripheral parking, (3) car pooling and those restraints necessary to ensure the effectiveness of these measures, namely, curb parking removal.

- Strategy 4 - Combined Strategy 1 and Strategy 3

VMT reductions are combined with the exhaust control measures in Strategy 1 above.

- Strategy 5 - Combined Strategy 2 and Strategy 3

The above strategies are considered conservative in their estimates of emission reduction possible; however, no strategy will precisely achieve the 64 percent reduction required even in the core area where VMT reduction impact is greatest. No consideration has been given to any high altitude retrofit package due to lack of data. The reduction achievable by implementation of this exhaust control measure will definitely be sufficient

Table Den.1. PERCENT REDUCTIONS ACHIEVABLE*
FOR CO (TOTAL EMISSIONS)

TOTAL (64% Reduction Required)	DENVER		CENTRAL AREA		CORE	
	Emissions (tons/day)	Reduction (percent)	Emissions (tons/day)	Reduction (percent)	Emissions (tons/day)	Reduction (percent)
1971	538.8	--	162.0	--	79.1	--
Federal New Car	357.6	33.6	101.8	37.2	42.9	45.8
Strategy 1	279.9	48.1	78.3	51.7	36.7	53.6
Strategy 2	263.5	51.1	73.5	54.6	34.4	56.5
Strategy 3	348.1	35.4	95.9	40.8	39.8	49.7
Strategy 4	272.9	49.4	74.0	54.3	34.1	56.9
Strategy 5	257.0	52.3	69.4	57.2	32.0	59.5

*Reductions from 1971 all include 1975 standards.

Table Den.2. PERCENT REDUCTIONS ACHIEVABLE*
FOR HC (TOTAL EMISSIONS)

TOTAL (32% Reduction Required)	DENVER			CENTRAL AREA			CORE	
	Emissions (tons/day)	Reduction (percent)	Emissions (tons/day)	Reduction (percent)	Emissions (tons/day)	Reduction (percent)	Emissions (tons/day)	Reduction (percent)
1971	105.8	--	20.4	--	8.7	--	8.7	--
Federal New Car	77.6	26.7	10.6	48.0	4.4	49.4	4.4	49.4
Strategy 1	72.4	31.6	9.0	55.9	3.7	57.5	3.7	57.5
Strategy 2	72.5	31.5	9.1	55.4	3.8	56.3	3.8	56.3
Strategy 3	76.6	27.6	10.0	51.0	4.1	52.9	4.1	52.9
Strategy 4	71.6	32.3	8.6	57.8	3.5	59.8	3.5	59.8
Strategy 5	71.7	32.2	8.6	57.8	3.5	59.8	3.5	59.8

*Reductions from 1971 all include 1975 standards.

in combination with Strategy 4 or Strategy 5 above to meet the required reduction for the core and central areas.

Based on the figures in Table Den.1, it is recommended that Strategy 5 (with the additional high altitude retrofit package) be adopted as the transportation control plan for Denver.

3.4.3 Conclusions and Recommendations

From the qualitative and quantitative analyses of existing data and recommendations for the control of transportation related carbon monoxide and hydrocarbon emissions, the following conclusions can be stated:

- The Federal standard for eight-hour carbon monoxide will require a 64 percent reduction in carbon monoxide emissions by 1977. The peak-hour oxidant data indicate a 32 percent reduction is required in the 6 - 9 a.m. hydrocarbon emissions.
- Federal new car standards will not be sufficient to meet the required reduction by 1977.
- No one control measure will be sufficient to meet the required carbon monoxide reduction.
- A region-wide plan is required to
 - (1) Prevent the deterioration of air quality in areas not currently exceeding the standards
 - (2) To reduce the region-wide contribution to the accumulation of pollutants in maximum concentration areas.
- The region-wide plan would consist of
 - (1) Those control measures which will effectively reduce the region-wide contribution to the formation of critical concentrations of which some combination of the following is considered most feasible and effective:
 - Inspection/Maintenance
 - High Altitude Retrofit
 - Pre-1968 Retrofit
 - (2) Those control measures which will reduce the emissions in critical concentration areas resulting from high density vehicle miles of travel at low average vehicle speeds.

- (3) Those long-term measures which in addition to those mentioned above will ensure that existing air quality in the region is not degraded. These measures should include:

- *Land use planning with attention to transportation related environmental factors
- *Tax reforms to reverse the existing encouragement for additional cars and/or VMT tax.
- *Planned development of a regional public transportation system in conjunction with land use planning.

On the basis of these conclusions, the following recommendations are made:

1. Establish immediately a testing facility to adequately measure the uncontrolled and controlled emissions at high altitudes. This facility should also test the proposed retrofit devices especially the high altitude modifications. Use this facility to test the findings of the Northrop study⁽²⁾.
2. Expand the regional monitoring network for carbon monoxide and oxidants.
3. On the basis of test results and the findings of the Northrop study, select an Inspection and Maintenance and retrofit program most effective at high altitudes and phase implementation of this program to achieve total impact by June 1976 at the latest.
4. On the basis of test results and findings of the Northrop study, determine the retrofit packages most effective for the Denver area (with special attention to high altitude retrofits) and phase implementation of this program to achieve full impact by June 1976 at the latest.

(2) Northrop Corporation, "Vehicle Emission Inspection and Control Program, Volume I - Summary," unpublished report, 15 November 1972.

5. Implementation of those VMT reduction measures directed at the central area (until extended monitoring indicates extension to other areas) and consisting primarily of:

- Regional bus network improvements
- Peripheral parking
- Car pooling

and those restraints necessary to ensure the effectiveness of these measures, namely

- Curb parking removal

Although further restraints such as taxation may be required to support a large modal shift, they require careful consideration of socio-economic impact and demand elasticity modeling before implementation.

6. Utilize the modal split, trip distribution, and economic analyses being carried out by the Council of Governments and the Regional Transportation District and long-range planning program to postulate alternative restraints and transportation impacts on the total transportation network. This effort will focus on long-term measures to assure the maintenance of ambient standards.
7. Update the emissions and air quality data base on the basis of monitoring and test results at least semi-annually during the period January 1973 to July 1976.
8. Redefine, if necessary, the air quality problem on the basis of the updated inventory and any modeling performed.
9. Re-evaluate and redefine the elements of the control strategy, where necessary, at least semi-annually between January 1973 and July 1976.

3.5 SUMMARY AND CONCLUSIONS-HOUSTON/GALVESTON, TEXAS

3.5.1 Air Quality and Emission Reductions

There is no identified carbon monoxide problem in the Greater Houston Area. An ozone measurement study was performed on the upper Texas Gulf coast between April and June of 1972. This study identified a regional photochemical oxidant problem of major magnitude. As a result of this study, the baseline maximum one-hour oxidant concentration was revised upward to 0.315 ppm (630 $\mu\text{gm}/\text{m}^3$).

After careful evaluation, a total hydrocarbon emission reduction goal of 75 percent was established to meet photochemical oxidant standards in the Greater Houston Area. Calculations were performed to determine the total hydrocarbon emissions from all sources including motor vehicles, and to estimate the reduction possible with present stationary source regulations and Federal motor vehicle emission controls. This initial evaluation determined that the ambient air quality standards could not be met by 1977, even with zero mobile emissions, unless hydrocarbon emissions from stationary sources are also reduced significantly.

3.5.2 Proposed Control Strategy

The proposed strategy is phased so as to take advantage of legislative or judicial remission, technology development and changes in requirements resulting from a better understanding of the air pollution problem in the Greater Houston Area. In its fully implemented form, it will allow air quality standards to be met by the 1977 due date. Phase I measures have substantial justification, either in terms of significant air quality improvement or other urban needs. Present justification for Phase II measures is tentative at best. The final decision to implement them must be based on a better demonstration of the need for further hydrocarbon emission reductions than is now available. Figure HOU-1 summarizes the emission reductions possible from implementation of Phase I and Phase II of this proposed control strategy.

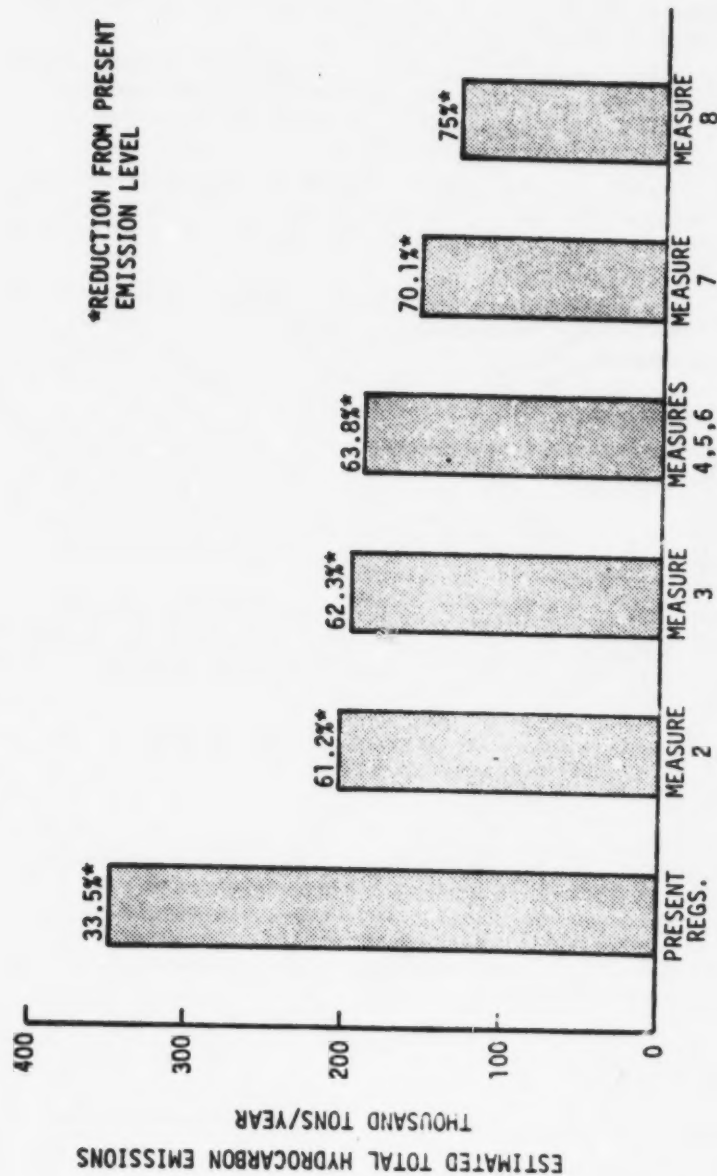


Figure HOU.1 Estimated Total Hydrocarbon Emissions in 1977 Resulting from the Proposed Control Measures

Phase I Measures

1. Continue evaluation of control measures - Expand the air monitoring program in the Greater Houston Area to include more stations and gas chromatography at selected stations. Initiate a regular review of the air quality and emission inventory data to determine if adjustment of the emission control strategy is required to meet ambient air standards.
2. Stationary source measures - Tighten and expand the Regulation V stationary source controls as recommended by the Texas Air Pollution Control Service's study. Broaden the coverage of Regulation V to include all counties in the region.
3. Mandatory inspection/maintenance - Implement an annual inspection/maintenance program for in-use vehicles. An idle emission test performed in conjunction with the annual safety inspection is the method recommended.
4. Mass transit - A substantial improvement in mass transit is required in the Greater Houston Area. Based on this need and recognizing the extensive studies that have been performed, it is recommended that Phase I of the Houston Transit Action Program be implemented as soon as possible.
5. Parking measures - It is recommended that parking measures be instituted in all high density areas. These include strict enforcement of existing parking regulations, elimination of preferential rates for all day parking, and establishment of procedures to control parking availability as adequate mass transit is provided.
6. Car pool incentives - Initiate a formal information program with the aim of increasing the amount of voluntary car pooling. This program should include a computer matching element.

It is estimated that measures 4, 5 and 6 will bring about a 3 to 5 percent reduction in VMT.

7. Fugitive and evaporative emission controls - (a) Promulgate regulations to control evaporative hydrocarbon emissions from all gasoline marketing levels. (b) Promulgate regulations to control all reactive hydrocarbon emissions from solvent users. (c) Promulgate regulations to attack fugitive losses from all process industries.

Phase II Measures

If at the end of the evaluation period in 1974 it is determined that additional hydrocarbon emission reductions are required, those reductions can be obtained through implementation of the following measure:

8. Motor vehicle emission reduction - (a) Retrofit a catalytic converter on all 1968-1974 automobiles and reduce the vehicle miles traveled during the summer and fall months by 30 percent or (b) no major vehicle retrofit program and reduce vehicle miles traveled by 50 percent during the summer and fall months. The method recommended to effect the vehicle mile reduction is gasoline rationing.

As is obvious, implementation of the Phase II measure would be very difficult. Rigorous objections at all levels of government, industry and the public can be expected. For that reason, it is not recommended unless and until the need for additional (over Phase I) hydrocarbon emission reductions are substantiated by additional ambient air quality monitoring.

3.5.3 Conclusions and Recommendations

Presented below are the major conclusions and recommendations that have emerged as a result of this study.

Conclusions

- Photochemical oxidants and total hydrocarbons are well above the national standards a significant portion of the time in the Houston area.
- Stationary source as well as mobile source reductions are required to allow the ambient standards to be met.
- There is no adequate definition of the actual effect that emission levels have on ambient air quality in the Greater Houston Area. The present air quality measurements and the accuracy of the emission inventory are not sufficient to develop this relationship.
- Significant reductions in hydrocarbon emissions can be obtained by tightening Regulation V.
- Annual inspection/maintenance is necessary to obtain full benefit from Federal motor vehicle emission controls.
- Traffic flow improvements offer only marginal positive contributions to air quality.
- A substantial improvement in mass transit is required in the Greater Houston Area. The Houston Transit Action Program is a major step in the right direction; however, it is questionable whether the key elements can be completed by the 1977 air quality deadline.
- Substantial mobile source emission reductions over those that can be achieved through individual vehicle emission controls can only be obtained by direct reductions in vehicle miles traveled.

- The use of vehicles cannot be significantly restrained without providing some alternate means of transportation.
- Pricing schemes (including taxes) to discourage auto travel are largely ineffective and heavily regressive.
- Gas rationing appears to be the most directly effective and administratively viable means of imposing VMT reductions.

Recommendations

It is recommended that the Phase I control measures be implemented. The measures have substantial justification, either in terms of significant air quality improvement or other urban needs. The final decision regarding implementation of the Phase II measure should be deferred until the need for additional (over Phase I) hydrocarbon emission reductions are substantiated by further ambient air quality monitoring and a review of the air quality standards in light of the cost to achieve them.

3.6 SUMMARY AND CONCLUSIONS-LOS ANGELES, CALIFORNIA

3.6.1 Air Quality in the South Coast Air Basin

Air quality measurements taken in the South Coast Air Basin show the air pollution to be a severe problem. The severity of the air pollution can be shown by at least three indices: (1) the extensive geographical area which experiences the problem, (2) the number of days per year that various established standards are violated, and (3) the number of pollutants which contribute to the problem.

Unlike areas which experience localized pollution from a limited number of point sources, the air pollution characteristic of Los Angeles is truly regional. The areal nature of the problem is the result of several factors. First, the major source of contaminants in the Basin is the automobile, which means the primary pollutants* are emitted from millions of spread out mobile sources (Figure LA.1). The low density of the region contributes to this by having thousands of miles of streets and freeways cutting around and through the 8000 or so square miles of the Basin. Finally, since the principal air pollution problem is photochemical oxidants; the primary pollutants are given the chance to diffuse before becoming involved in the photochemical reactions which ultimately generate ozone (O_3).

The number of days on which different air quality standards is violated varies as a function of pollutant and time of year. High photochemical oxidant levels occur predominantly during the summer months whereas the CO levels are generally highest during the winter months. The seasonal variation of selected pollutants is seen by examining data compiled for the west San Fernando Valley (Figure LA.2). This valley experiences neither the best nor worst air in the Basin, and consequently, can be viewed as "typical".

* Primary pollutants are those pollutants which are emitted directly into the atmosphere, e.g., CO, HC, NO; secondary pollutants are those which have resulted from a transformation process involving primary pollutants, e.g. NO_2 , O_3 .

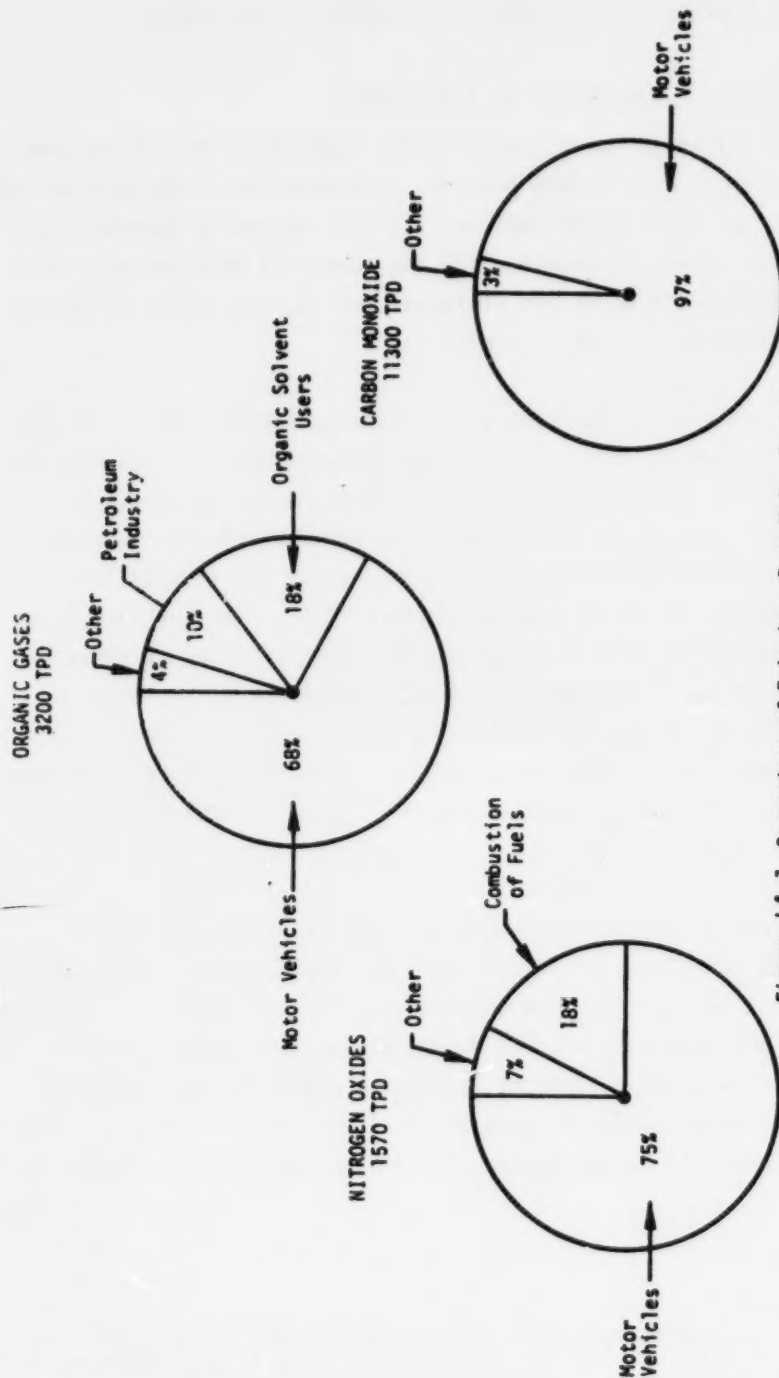


Figure LA.1 Percentage of Emissions From Major Sources
in the South Coast Air Basin - 1970

Source: State of California, The Resources Agency, Air Resources Board,
California Emission Inventory - 1970, July 1972, p. 45.

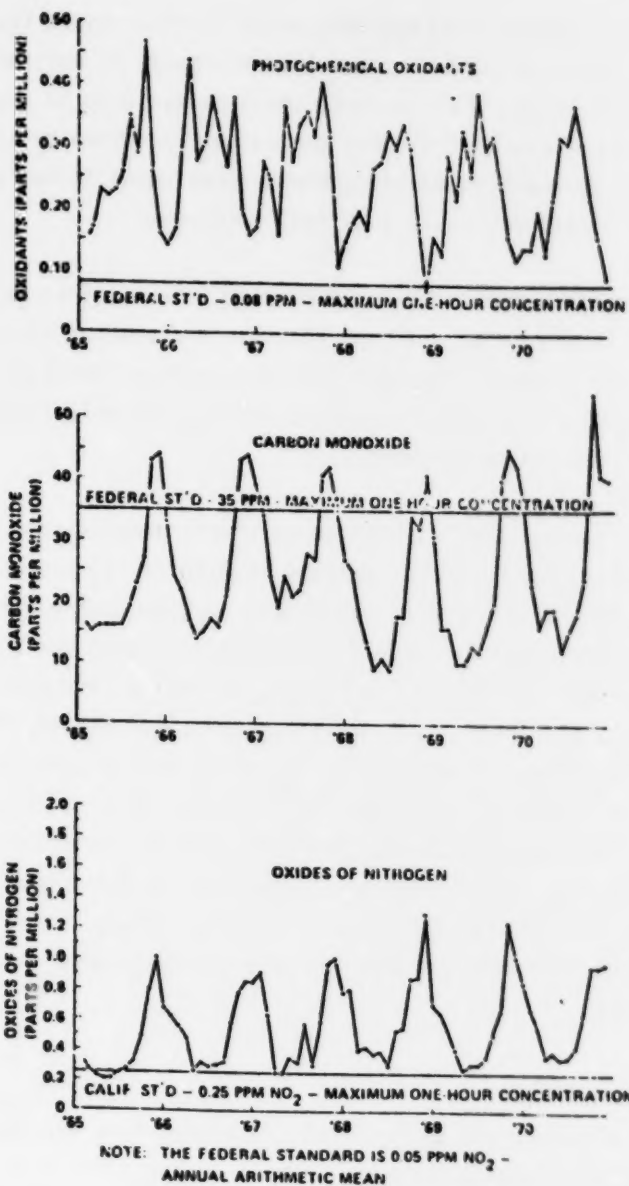


Figure LA.2. Major Air Pollutants - Monthly Maximum Hourly Averages
West San Fernando Valley (Monitored in Reseda) 1965- 1970.

Source: Branch, M. C., and E. Y. Leong (eds.), Research Investigation-
Air Pollution and City Planning, Environmental Science and
Engineering, University of California, Los Angeles, 1972, p. 6.

The oxidant control strategy discussed in this report involves the control of high reactive organic gases (hydrocarbons) as defined by the Los Angeles APCD Rule 66. This control approach was used in the State Air Implementation Plan, and has been tentatively accepted by EPA. As a result of this approach, some hydrocarbons considered to be reactive by EPA, are not considered in this control strategy.

The high yearly ambient oxidant reading is considered to be directly proportional to the amount of high reactive hydrocarbon emissions for that year. In other words, straight line proportional rollback of high reactive hydrocarbon emissions is used to predict the emissions reduction needed to meet the oxidant standard.

The base year of 1970 is used to make this prediction. On August 6, 1970, the yearly one-hour high oxidant reading of .62 ppm was recorded at Riverside. The .67 ppm year high oxidant reading used by the California Air Resources Board (ARB) in the air implementation plan has since been rejected by the ARB. The State Plan showed a total of 195 tons/day of stationary source high reactive hydrocarbon emission, and 33 tons/day from aircraft in 1970. The 1970 emissions from other mobile sources (i.e., on-highway light and heavy duty gasoline vehicles and motorcycles) are 1023 tons/day. As indicated this number does not include the emissions from off-highway gasoline usage. However, this usage is considered negligible on the basis of data obtained from the ARB staff, which showed that current off-highway gasoline usage accounts for only slightly more than 2 percent of gasoline sales.

3.6.2 Control Strategy

The relationship between air pollutant emissions and ambient air quality is still not well understood, despite major efforts to develop both sophisticated analytical and statistical models. The inaccuracies in the ability to predict air quality result from many factors, some of which are:

- Inadequate and questionable emission inventories
- Questionable air quality data
- The representativeness of test cycles to actual driving patterns; e.g., 7-mode vs. CVS
- The uncertainties of the real effectiveness of various control strategies.

The control strategy recommendations presented are based on proportional rollback techniques that relate estimated emissions to air quality in a linear fashion. This has been done primarily because of the time constraints of the study. The validity of this technique is highly questionable and consequently does not serve as an adequate basis on which to implement severe control measures.

Full implementation of the control measures outlined should allow attainment of the air quality standards by the 1977 target date. Implementation of Phase I measures can be justified on the basis of air quality improvements at reasonable costs. The impact of implementing the Phase II control measures is staggering. This study had neither the time nor the data base to fully evaluate the social, political, and economic ramifications of such a measure. Hence, it cannot be recommended at this time although it would, in all probability, result in the desired goal.

The control measures outlined are not new and have been proposed elsewhere; no "magic solution" was found and only incremental improvements can be expected from each strategy. The primary reason for this is a host of control options were evaluated, the large majority of which proved to be relatively ineffective. The California Air Resources Board is actively engaged in field testing a variety of control strategies and has extensive experience in the field of air pollution control; it would be a mistake to usurp their efforts and knowledge with massive unproven control measures.

The severity of the air pollution left few alternatives for measures which would be adequate to accomplish the program requirements.

Phase I Measures:

1. Evaporative Controls - Accelerate the evaluation program of evaporative control devices for 1966-1969 vehicles. At the earliest date, if the devices are shown to be effective and available, a mandatory installation program should be implemented.
2. Oxidizing Catalytic Converters - Accelerate the evaluation program of oxidizing catalytic converters. If these converters are effective and become available, incentives should be made to encourage their use on 1966-1974 vehicles.
3. Mandatory Inspection/Maintenance - Implement a program of inspection and maintenance for in-use vehicles. The program recommended is the second stage expansion of the recommended program of the Governor's Task Force on Periodic Vehicle Inspection and Maintenance. This measure will provide significant reductions in motor vehicle emissions and is necessary to derive the full benefit from both new and used car emission controls. This should result in a reduction of ten to twelve percent of the reaction hydrocarbons left uncontrolled in 1977 (approximately 40 tons/day).
4. Mandatory Conversion of Fleet Vehicles to Burn Gaseous Fuels - Implement a program requiring the conversion of all fleet vehicles of model years 1970-1974 to use a gaseous fuel. This measure will significantly improve the emissions from vehicles which presently account for a disproportionate share of the miles traveled in the South Coast Air Basin. The reduction from this program is estimated to be approximately 12 tons/day of reactive hydrocarbons.
5. Evaporative Loss Controls - Implement a program to substantially reduce hydrocarbon losses from fueling operations, specifically from the loading of underground storage tanks at the gasoline

station and from the service pump to the automobile fuel tank. The control of these marketing losses is estimated to be approximately 65 tons/day of reactive hydrocarbons.

6. Additional Stationary Source Controls - Stationary source controls were not evaluated as part of this study; however, as mobile source controls become more effective, the proportionate contribution of stationary sources to the problem will increase. The emission reductions claimed from this strategy were calculated by the EPA and have tentatively been accepted. They are as follows: 6 tons/day from dry cleaning vapor control, 25 tons/day from degreaser substitution, and 45 tons/day from a 50 percent strengthening of the Los Angeles County Air Pollution Control District's Rule 66. All in all, approximately 76 tons/day of reactive hydrocarbons can be controlled from additional stationary source controls.
7. Mass Transit - The level of mass transit available presently is totally inadequate to handle any substantial increases in ridership. Improving mass transit both in terms of frequency and efficiency of service and the breadth of coverage in areas served, is a necessary first step to attract additional riders. It is also needed for making any measures which discourage private auto use more effective. Finally, should Phase II be implemented, it is imperative as an alternative mode of travel. A much closer examination should be given to establishing express bus and carpool lanes on certain freeways. Park-and-ride facilities, as well as bicycling, should be encouraged in more areas of the Basin.

Implementation of a series of mass transit improvements plus a variety of incentives to discourage the private use of the automobile should result in a 5-8 percent reduction of VMT in 1977. The reduction in reactive hydrocarbons is estimated to be no more than 5 percent of the remaining controllable emissions or approximately 17 tons/day after the implementation of the Phase I measures.

Phase II Measure:

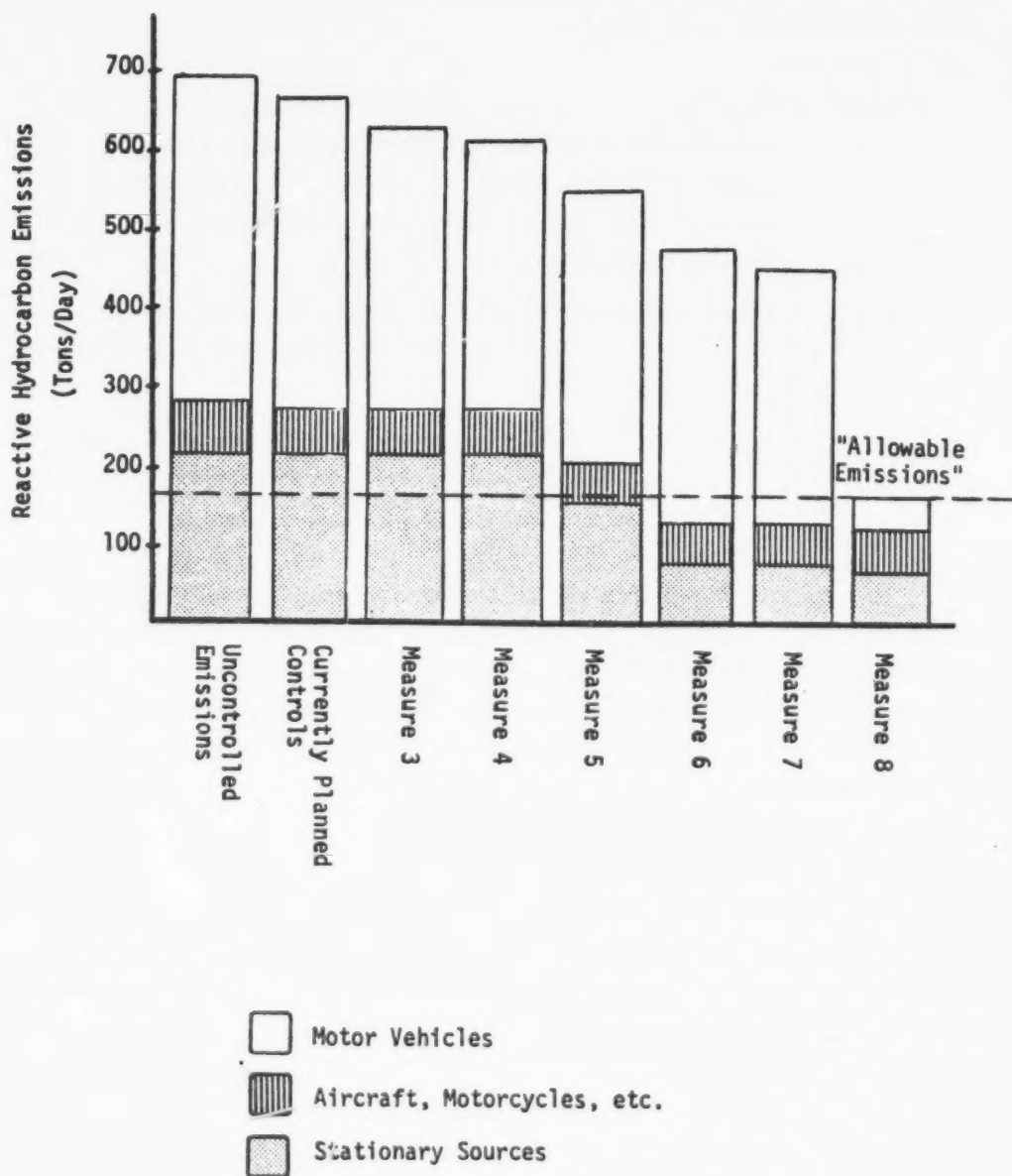
8. a) VMT Reduction - Implement a massive program to significantly reduce the vehicle miles traveled within the Basin, hence eliminating the major source of hydrocarbon emissions. This can probably be done most effectively by rationing the gasoline supply. Rationing can be accomplished either by limiting the supply to the actual consumers from the gasoline station or from the refinery to the service station; or

b) Evaporative Retrofit Device and/or Oxidizing Catalytic Converters with VMT Reduction - If upon completion of the Air Resources Board's studies of these controls (Measures 1 and 2), it can be shown these devices can make a significant impact on the air quality improvement of the Basin, implement programs to require their installation. A detailed examination should be made of costs and benefits to be derived by a mandatory retrofit program. This will become more important as time passes and the older cars represent a smaller contribution to the overall problem.

Assuming a given reduction in VMT is the equivalent percent reduction in gasoline consumed, an 87 percent VMT reduction is required beyond the Phase I measures. This would result in approximately 292 tons/day of reactive hydrocarbons not being discharged into the atmosphere (283 tons/day from vehicular emissions and an additional 9 tons/day from marketing losses).

This same level of control could be accomplished by an 81 percent VMT reduction after implementing mandatory installation of the controls described in Measures 1 and 2 (evaporative control devices and oxidizing catalytic converters). The approximate reductions in reactive hydrocarbons would then become: 26 tons/day from evaporative control devices; 84 tons/day from oxidizing catalytic converters; 8 tons/day from marketing losses; and 174 tons/day from an 81 percent VMT reduction after all other control measures had been implemented.

Figure LA.3. The Impact of Proposed Control Strategy on Reducing Reactive Hydrocarbon Emissions (1977)



3.7 SUMMARY AND CONCLUSIONS-NEW YORK CITY

3.7.1 Air Quality

At one or more points within the boundaries of New York City, the NAAQS's for CO, O_x, and NO_x are exceeded. The principal features of New York's problems are as follows:

- CO - The highest levels are observed in the downtown and midtown sections of Manhattan where maximum eight-hour concentrations of 45 ppm (parts-per-million) and 32 ppm, respectively, have been recorded. The maximum eight-hour standard is 9 ppm.
- O_x - The general New York area appears to have maximum one-hour, oxidant levels of about 0.18 ppm, compared with a national standard of 0.08 ppm.
- NO_x - Congested areas have maximum one-hour NO_x levels of about 0.08 ppm, while other areas are approximately half that value. The standard is 0.05 ppm annual average.

It should be noted that photochemical oxidants, unlike CO and NO_x are not emitted directly by motor vehicles. Hydrocarbons (HC), which are emitted by motor vehicles, undergo a complex system of reactions to produce O_x. It is assumed in this report, as has been assumed in most other work of this kind, that atmospheric levels of O_x are proportional to hydrocarbon emission rates. Therefore, O_x levels can be controlled by reducing hydrocarbon emissions.

3.7.2 Emission Reductions Needed

For the most-critical areas, the estimated percentages by which 1970 emissions must be lowered to meet the national air quality standards are as follows:

- CO - downtown - 80 percent reduction
midtown - 72 percent reduction

- O_x - 56 percent reduction of HC
- NO_x - 38 percent reduction in congested areas
0 percent reduction elsewhere

3.7.3 Proposed Control Strategy

The control strategy developed for use in New York City is presented in the following paragraphs. In some cases, such as the hardware-based control measures, the emission reduction potentials could be quantified. However, for others such as very localized traffic flow improvements, a lack of detailed traffic data prevented a quantitative assessment of the actual emission control potential. The latter class of control is used only in downtown Manhattan where an additional reduction in CO emissions (beyond that obtained by vehicle turnover and the hardware measures) is needed to reach the standard. It should also be noted that in estimating the emission reductions of CO and HC required to meet the respective CO and O_x federal standards, the highest measured ambient levels of CO and O_x were utilized for the rollback calculations. This is more stringent than the Federal EPA requirements, which allow the use of the second highest measured values.

The expected vehicle emission reduction percentages for the "hardware" control measures, i.e., retrofit and inspection programs, are tabulated in Table NY-1. The specific control packages are described below:

- Retrofit Package - this will consist of engine modifications (retarded spark, etc.) and a catalytic converter. NO_x controls might be incorporated but these were not included in emission calculations. A twice yearly inspection will be used to insure compliance.
- Inspection/Maintenance - a loaded emission test will be made on taxis three times per year and on private automobiles once annually.

It appears that only the area of downtown Manhattan around the Canal Street Post Office might require VMT reductions. However, the biggest emission source in this area (trucks, even after being retrofitted) is not

TABLE NY.1

ASSUMED VEHICLE EMISSION REDUCTIONS FOR HARDWARE CONTROL MEASURES

<u>Control Measure</u>	<u>Emission Reduction</u>		
	<u>CO</u>	<u>HC</u>	<u>NO_x</u>
A - Retrofit of Heavy-Duty, Gasoline-Powered Vehicles	50	50	0
B - Inspection/Maintenance of Taxis	10	12	0
C - Inspection/Maintenance of Private Cars	10	12	0

considered suitable for VMT reduction, because of the potential economic harm which might result. The recommended additional control measure for this area is as follows:

- Pragmatic Flow Improvement/VMT Reduction Approach - the high CO levels recorded at the Canal Street sampling station are due in large part to the terrible congestion problems on this artery. For this reason, the downtown CBD is quite affected by general traffic flow improvements such as the on-going TOPICS program and the new westside highway construction. These programs should be augmented by strict enforcement of parking regulations and the anti-cruising ordinance for taxis.

The techniques described in the initial sections of this report were utilized to estimate emissions obtained by application of four hardware control measures by 1977:

- Vehicle Turnover
- Heavy-Duty Vehicle Retrofit and Inspection
- Taxi Inspection/Maintenance
- Private Automobile Inspection

The results are tabulated together with 1970 baseline emissions in Tables NY-2 and NY-3. The conclusions drawn from these results are in the following paragraphs.

- CO Emission Controls

Apparently, the hardware control measures alone could enable all areas of New York City, except for part of the downtown Manhattan CBD, to meet the ambient air quality standard for carbon monoxide in 1977. Because of the conservative rollback estimates used for this analysis, there is a good chance that even this area will meet the standards with no additional controls. Furthermore, TOPICS improvements will improve traffic flow and help reduce

TABLE NY.2. AIR POLLUTANT EMISSION ESTIMATES FOR THE "WORST" SQUARE MILES
IN DIFFERENT AREAS OF NEW YORK CITY (Ton/Year)

Case	Downtown (134)			Midtown (193)			Bronx (315)			Brooklyn (75)			Queens (195)		
	CO	HC	NO _x	CO	HC	NO _x	CO	HC	NO _x	CO	HC	NO _x	CO	HC	NO _x
1970-U	20,730	4,870	9,019	9,751	2,053	4,381	5,667	1,149	1,381	8,462	2,813	2,533	10,915	2,700	3,431
1975-U	13,998	3,765	5,267	4,452	1,228	2,297	3,679	643	1,372	5,825	2,111	2,537	7,412	1,761	3,438
1977-U	10,804	3,029	4,962	3,236	981	2,142	2,614	436	1,271	4,159	1,791	2,392	5,218	1,334	3,234
1984-U	6,123	2,483	4,729	1,910	828	2,051	964	332	1,184	1,569	1,630	2,267	1,813	1,121	3,055
1977-A	6,931	2,149	4,962	2,317	773	2,142	2,355	376	1,271	3,752	1,698	2,392	4,662	1,210	3,234
1977-B	10,755	3,020	4,962	3,188	972	2,142	2,614	436	1,271	4,159	1,791	2,392	5,218	1,334	3,234
1977-C	10,638	3,003	4,962	3,174	972	2,142	2,430	418	1,271	3,871	1,765	2,392	4,840	1,300	3,234
1977-A11	6,716	2,114	4,962	2,207	755	2,142	2,171	358	1,271	3,464	1,672	2,392	4,304	1,176	3,234
Allowable	4,146	NA	5,592	2,730	NA	2,716	5,350	NA	MS	7,988	NA	MS	10,304	NA	MS

Abbreviations:

U = uncontrolled (vehicle turnover alone).

A = control measure A (retrofit and inspection/maintenance of heavy-duty vehicles).

B = control measure B (inspection/maintenance of taxis).

C = control measure C (inspection/maintenance of personal cars).

A11 = all of the control measures.

NA = not applicable, HC is treated on an area-wide basis (see Table NY.3).

MS = currently meets standards.

CO emissions on a short-term basis. The additional help from strict enforcement of existing parking regulations and reduced taxi cruising will give more assurance of meeting the standard.

- HC Emission Controls

The very preliminary O_x air quality data available for New York indicate that a 56 percent reduction in hydrocarbon emissions from 1970 levels is needed area-wide to meet the O_x air quality standard. The emission estimates for 1977, with the hardware controls in effect, show a projected emission reduction of 53 percent. Within the accuracy of the air quality, emission factor and traffic data sets, there is no significant statistical difference between these numbers. Nevertheless, because the projections indicate that stationary sources will be responsible for almost two-thirds of the 1977 hydrocarbon emissions (assuming implementation of the hardware control measures) and most of these sources fail to meet existing NYC standards, the transportation controls should be augmented by rigid enforcement of the existing hydrocarbon emission regulations.

- NO_x Emission Controls

Like the O_x data, air quality data for NO_x are quite limited. The emission projections for 1977 imply that vehicle turnover will enable New York to meet the NO_x air quality standards with no further reductions needed. Nevertheless, the situation should be analyzed more thoroughly during implementation of the plan to insure that the standard will be met.

3.8 SUMMARY AND CONCLUSIONS-PHILADELPHIA, PENNSYLVANIA

3.8.1 Air Quality

The second highest measurement of carbon monoxide in Philadelphia during 1971 was 22.5 milligrams per cubic meter eight-hour average measured at 20th and Race Streets. The national primary standard of 10 milligrams per cubic meter eight-hour average must be achieved by July 1977.

3.8.2 Emission Reduction Required

A reduction of 56 percent from 1971 emission levels of CO emitted from mobile sources throughout the City is estimated to be needed to achieve the required reduction in ambient air concentrations to the level of the standard. Estimated mobile source emissions of CO in 1971 was 302,000 tons per year total for the City and 25,500 tons per year for the Central Business District (CBD). By 1977, it is estimated that emissions must be reduced to 133,000 tons per year. With no transportation control strategy implemented, it is estimated that a 47 percent reduction will be achieved total for the City and 61 percent for the CBD, due largely to the effect of Federal new car emission controls.

3.8.3 Control Strategy

- Control Measures Considered

Control measures which can be used to reduce mobile source emissions and their estimated effects are as follows:

Inspection/Maintenance - One of several inspection alternatives needed to maintain engine performance and emission controls at lower emission levels. Estimated reduction: 4-6 percent.

Inspection/Maintenance with Retrofit - One of the several inspection alternatives with the additional requirement that all pre-1968 vehicles be retrofitted with emission control devices comparable to new vehicle emission controls. Estimated additional reduction is less than 1 percent.

Curbside Parking and Loading Regulations - Enforcement of regulations in order that programmed TOPICS traffic controls are effective. Estimated reduction: 3 percent for the CBD.

Electrification - Replacement of motor buses with electrified vehicles results in an estimated reduction of less than 1 percent.

Gaseous Fuel Conversion - Emission rates expected from gasoline fueled 1975 model years and beyond compare favorably with those rates from gaseous fueled vehicles. Conversion of pre-1975 fleet vehicles would have short-term, negligible effect.

Increase Mass Transportation Ridership - Control measures which have the potential for increasing ridership are as follows:

- Center city tunnel connection of suburban rail stations
- Additional park and ride facilities
- Capacity increases
- Shorter headways
- Security force to eliminate crime in stations and transit cars
- Rider amenities (appearance, lighting, better seating, station upgrading)
- Unified fare system
- Work staggering in CBD
- Circumferential transit
- Commuter rail and subway extensions

Ridership increases from 1 percent to 20 percent are estimated to reduce emissions from less than 1 percent to 7 percent.

Restraints - Possible restraints are the prohibition of certain classes of vehicles from congested areas (congestion pass) and parking space control for inhibiting the movement of vehicles into areas where limited parking is available. A prohibition of 100,000 vehicle trips per day are estimated to reduce emissions 2 percent.

VMT Controls - The responsible planning agencies should factor air quality effects into their transportation planning.

CBD Priority - The priority to those control measures which preferentially control emissions from the CBD or other yet to be determined areas of high pollutant emission density.

Car Pools - Low density population in the suburban areas discourages utilization of car pools as an attractive transit mode.

Vehicle Free Zones - Attractive pedestrian malls have the potential for helping to revitalize center city commerce. However, experience in other urban areas has shown that displaced vehicular traffic tends to be relocated rather than reduced.

● Proposed Control Strategy

Selection requires the consideration of comparative cost effectiveness of the alternative control measures and the technical

and institutional obstacles. Data were available for only a limited analysis of cost effectiveness. Emission related control measures, such as inspection/maintenance programs, have technical limitations which need to be overcome and also have substantial cost effective deterrents. VMT reduction control measures, such as mass transit improvements and traffic restraints, present funding problems for the intensive network required in the case of mass transit and severe institutional obstacles in the case of traffic restraints. Traffic restraints should not be implemented without alternative means of travel by mass transit.

Control measures are needed to reduce mobile source emissions by 26,000 tons CO per year (9 percent). The recommended control strategy for Philadelphia is as follows:

Curbside Parking and Loading Regulations - Estimated to achieve a reduction of 4000 tons/year.

Inspection/Maintenance (Engine Parameter Without Retrofit) - Estimated to achieve a reduction of 10,000 tons/year.

Increase Mass Transportation Ridership - Potential reductions of 6000 tons/year to 10,000 tons/year are estimated for a 10 percent increase in ridership.

Restraints - Prohibition of certain classes of vehicles from congested areas are estimated to result in a reduction of 6000 tons/year per 100,000 daily vehicle trips.

VMT Controls - Factor effect of increase of vehicular miles of travel on air quality into transportation planning.

CBD Priority - Give priority to those control measures which preferentially control emissions from the CBD or other yet to be determined congested areas.

With substantial increases (more than 10 percent) in mass transit ridership, it is estimated that the air quality goal can be achieved by implementation of the first three control measures listed. However, considering the time constraints and economic obstacles to implementation of most of the mass transit control measures, traffic restraints at least for the short term are likely to be needed.

Two concurrent implementation tasks requiring immediate action are the studies and surveys required to make the necessary corrections and additions to the data base, and immediate decision mass transit funding. Following update of the data base, a better defined mass transit improvement program may require additional funding (deferred decision funding). Funding delays may prevent the implementation of all of the required mass transit control measures within the time constraints.

Control strategy for the reduction of carbon monoxide from mobile sources has a comparable effect on hydrocarbon emissions and thus corresponding reductions in photochemical oxidants are projected. Increased average speeds from the implementation of TOPICS traffic controls or VMT reductions may result in an increase in nitrogen dioxide emissions per mile traveled but this emissions/average speed relationship has not been quantified to date⁽¹⁾.

(1) D.S. Kircher and D.P. Armstrong, "An Interim Report on Motor Vehicle Emission Estimation," Environmental Protection Agency, October 1972.

3.9 SUMMARY AND CONCLUSIONS-PHOENIX/TUCSON, ARIZONA

3.9.1 Air Quality and Emissions Reductions

The development of a comprehensive transportation control strategy constitutes a major step towards achieving the desired air quality standards in the Phoenix-Tucson area. Unfortunately, existing Set II pollutant concentration data for Tucson and other areas outside Phoenix are not sufficient for use as a basis for forecasting air quality in those areas. For this reason, control measures included in this study could not be evaluated for use specifically in Tucson. However, it is recommended that the general results of this study be used as much as possible in current and future Tucson air quality programs.

The proposed transportation control strategy is specifically designed to meet the hydrocarbon (HC) and primary oxidant (Ox) standards by 1975, and the carbon monoxide (CO) standard by 1977. The strategy does not directly address itself to achieving the nitrogen dioxide (NO₂) standard. The Arizona State Implementation Plan was reviewed and the 1969 emissions inventory and air quality data from this plan were used as the baseline for making projections. Estimates of future air quality were made based on current stationary source control policies and forecasted growth. The results of this study must be viewed within this context. Specifically a 50 percent reduction in CO and a 25 percent reduction in oxidants above that achieved through ongoing and/or planned programs is needed. Control of CO (8-hour maximum) becomes the constraining element of the control plan.

3.9.2 Control Strategy Specification

A wide variety of promising control measures were examined during the course of this investigation. Selection of the "best" measure for incorporation into the proposed transportation control strategy was based, in part, on two general criteria:

- (1) Maximum cost effectiveness with proven reliability
- (2) Widest possible public acceptance with minimum socio-economic impact.

The proposed transportation control strategy developed for the Phoenix area consists of two distinct phases. Phase I is designed to accomplish substantial improvements in air quality for the 1975 through 1977 period. Based on analysis of current data (1969), however, additional controls may be necessary. Consequently, a Phase II program has been formulated in order to insure compliance with the standards. The need for implementing Phase II should be based on the results obtained from Phase I. The measures associated with both phases of the proposed transportation control strategy are listed below:

Phase I

- Air quality surveillance system
- Mandatory vehicle inspection/maintenance for all vehicles
- Retrofit emission control for all pre-1968 vehicles
- Evaporative emission control.

Phase II (if necessary)

- Vehicle exchange program
- Limited second vehicle registration

A brief description of each measure is presented in the following. A more definitive description of these measures appears in the text of the city report.

Air Quality Surveillance System

The surveillance system proposed in this strategy uses the existing system and the system recommended by the Arizona State Implementation Plan as a foundation for developing the capability for monitoring Set II pollutants in the Phoenix-Tucson problem area. The recommendations in this strategy consist mostly of expanding the use of CO and O_x monitors through the metropolitan area to provide for reasonable accuracy in evaluating peaks and trends in air quality and in assessing the effectiveness of the implementation plan. It has been found that sites used or proposed prior to this strategy can generally be used and that they provide an effective

distribution of monitors. The approximate cost of equipment for the system proposed in this strategy is \$24,000 and \$33,000. In addition, the MCHD mobile lab is regarded as a highly useful means of determining the spread of pollutant concentration and of identifying the need for longer-term monitoring and source control.

Mandatory Vehicle Inspection/Maintenance

One of the key components of the transportation control strategy involves a mandatory program of vehicle inspection/maintenance. Such a program will yield not only moderate emission reductions from the present vehicle fleet, but will also insure the proper operation of advanced control systems as they are introduced into the automobile population. It is this second factor that, in the long run, will have the largest impact on air quality.

Current studies indicate that the most cost-effective program involves a yearly exhaust emission inspection under load, followed as necessary by fuel ratio, ignition system (misfire), air cleaner, and PCV valve. Pass/fail exhaust emission criteria should be established to obtain the necessary emission reductions. A rejection rate of 30 to 40 percent may be required for the first year. The program should include a certification of service garages involved to insure reliable maintenance repair. Any retest of emissions after maintenance should be made optional. Estimates of potential emission reduction for the total population are 12 percent for hydrocarbons, 10 percent for carbon monoxide, and 0 percent for oxides of nitrogen. These reductions can be achieved for an annual cost of between \$5 and \$15 per car.

Retrofit Emission Control

The second recommended control measure consists of retrofitting the pre-1968 portion of the vehicle population. Basically, there are two retrofit approaches that are suitable for use in the Phoenix metropolitan area. The first one -- Vacuum Spark Advance Disconnect (VSAD) -- is particularly attractive for use on older vehicles in terms of potential emission reduction, cost, reliability and ease of implementation. Costs, including labor and with a simple override mechanism, should be from \$15 to \$30. Some

deterioration in fuel economy and driveability will occur on the average. Overheating may be a serious problem, especially during hot weather.

The other retrofit approach -- Lean Idle Setting (LIS) -- has good possibilities except for a high probability of owner or mechanic tampering. This procedure involves the additional leaning out of the air/fuel ratio beyond the manufacturer's specification. The cost per adjustment should be nominal -- \$3 to \$6 -- and fuel economy should improve slightly on the average. This modification is theoretically simple, but present mechanic ability and instrumentation limitations indicate the need for substantial improvement.

The combined emission reduction potential for both retrofit devices was computed as 25 percent for HC, 9 percent for CO, and 23 percent for NO_x. Again, this is consistent with current EPA estimates. In order to insure proper operation of these two systems, especially LIS, it is suggested that both be incorporated into the annual inspection program.

Evaporative Emission Control

The third element of the control strategy calls for the control of evaporative losses. Vehicle operation (carburetor and gas tank) and gasoline marketing (gas tank and storage tank filling) represent the two main sources of hydrocarbon evaporative losses in the Phoenix area. For controlling losses from the inuse fleet (pre-1971), it is recommended that the Reid Vapor Pressure (RVP) for all gasoline marketed in the Phoenix area be controlled seasonally. This should yield more than a 30 percent reduction in vehicle operating losses with moderate impact (approximately 1-2¢ per gallon) on overall marketing operations. Some driveability problems may occur (during start-up), although they should be of a minimal nature. The photochemical reactivity of the evaporated hydrocarbons may be altered by changing the RVP, but it appears that the change will be small.

Several methods are available for controlling evaporative losses from gasoline marketing. These include a totally enclosed transfer system used with either an adsorber, condenser or vapor return system. Approxi-

mately 70 percent of the vehicles on the road (mostly domestic) can be serviced from one adaptive system. The average costs of equipping service stations in the Phoenix area with evaporative recovery systems should run about \$2000 per station.

Vehicle Exchange Program

All things considered, older vehicles (pre-1968) emit higher emissions per mile than do later model automobiles. The Vehicle Exchange Program is designed to take advantage of this situation by limiting the importation of pre-1968 vehicles and by replacing some of the older vintage cars with newer, lower emitting vehicles. Considerations should be given to limiting out-of-state vehicle registration for pre-1968 cars after 31 December 1973. This would have the effect of reducing the aggregate exhaust emissions by about 3 percent.

Coupled with this would be a program to replace a segment of the older in-use cars with newer state and local government vehicles. One phase of this program would be to increase the rate of turnover of state owned vehicles to around 50 percent per year. Based on the current size of the state fleet, approximately 5000 cars would be available for exchange with pre-1968 vehicles on a yearly basis.

Criteria for exchange would have to be developed, based upon income considerations, in order to maximize program effectiveness. This combined program would be of short-term value, since by 1980 only about 3 percent of the vehicle population will consist of pre-1968 automobiles. The administrative costs of this program should only add a small increment to ongoing registration costs. However, the costs associated with exchanging these vehicles may be on the order of several million additional dollars annually.

The net effect of both programs in terms of emission reduction potential should be around 3 percent.

Limited Second Vehicle Registration

A preliminary assessment of the impact of the foregoing measures on air quality indicates the potential need for additional vehicle control. Specifically, it appears that up to 30 percent reduction in vehicle miles traveled (VMT) -- implying a need for an additional thirty percent air quality improvement -- may be required to achieve the national standards. The uncertainty in this estimate is closely related to the uncertainty in the baseline emissions data and limitations in the current methods used for predicting future air quality.

One approach for insuring such a reduction in VMT is by restricting the use of second and third family cars. This could be accomplished through the registration process, but the details and implications of a specific program would have to be very carefully assessed in terms of the political, institutional, legal and socio-economic impact on the Phoenix area. One positive benefit of such a program would be more efficient use of the family's primary vehicle which in turn would tend to encourage car pooling and some additional use of the mass transit system. Variances on this restriction could be granted if the vehicle were converted over to operate on gaseous fuels.

Preliminary estimates of the carrying capacity of the Phoenix transportation system indicate sufficient flexibility to accommodate a substantial portion of the affected motoring public. It should be re-emphasized, however, that vehicle use restriction control measures should not be implemented until further analysis (using refined air quality data and improved forecasting techniques) can demonstrate the inherent need.

Application of the proposed control strategy on forecasted Set II concentration levels for the Phoenix area yielded the following results:

- Hydrocarbon levels (6-9 AM Max) are well below the standard by 1975
- Carbon Monoxide levels (1 Hr Max) are well below the standard by 1977

- Carbon Monoxide levels (8 Hr Max) are within the standard by 1977
- Nitrogen Dioxide levels (annual) are substantially above the standard through 1980
- Photochemical oxidants levels (1 Hr Max) are within the standard by 1975

The variances in predicted air quality for CO and Ox vis-a-vis the standards are well within the limits of uncertainty associated with the data base and methods of forecasting.

3.10 SUMMARY AND CONCLUSIONS-PITTSBURGH, PENNSYLVANIA

3.10.1 Air Quality and Emissions

It was found that while the National Ambient Air Quality Standards for both carbon monoxide and oxidants are being exceeded at the present time, only the CO emissions will constitute a problem by 1977. This is because, although the FMVECP together with the planned controls on stationary sources will not, of themselves, quite achieve the reduction necessary to meet the oxidant standards by 1977, the transportation control strategies which will be required to attain the standard for CO by that time will also satisfy the requirement for reduction of hydrocarbon emissions sufficient to attain oxidant standards.

Tables Pitt.1 and Pitt.2 show the expected emissions and ambient concentrations for 1970 through 1986.

3.10.2 Control Strategies

In order of preference, the recommended strategies are:

<u>STRATEGY</u>	<u>AMOUNT OF ROLLBACK EXPECTED</u>
Inspection and maintenance (affects entire Region)	9% (CO); 10.8% (HC)
Traffic flow improvements through the upgrading of existing streets (affects Zone 1 only) <u>Strategy I</u>	1.4% (CO & HC)
Increase daily parking rate by \$1.45, use existing parking space in fringe areas, and improve short-term mass transit (affects Zone 1 only) <u>Strategy II</u>	5.5% (CO & HC)
Retrofit program (use of oxidizing catalytic converters) (affects entire Region)	8.2%* (CO & HC)

The amounts of rollback shown are taken for each strategy as though it were the only one to be adopted. The actual amounts expected as a result of the total program package are shown below for CO.

*Note: Only one quarter of available retrofit reduction was allowed. See City Report.

	Successive Reductions And Resultant Emissions Rates
1972 CO emissions from motor vehicles, Zone 1 (the "Baseline" value)	27,111 kg/day
Less expected reduction from FMVECP (51.6% of baseline)	<u>13,991</u>
1977 vehicular CO emission rate, no strategies	13,120
Less 1.4% emission reduction expected from traffic flow improvements (2% increase in average speed)	<u>184</u> due to <u>Strategy I</u> 12,936
Less 5.5% emission reduction expected from parking strategies and improvements in short-term mass transit (5.5% decrease in VMT within Zone 1)	<u>711</u> due to <u>Strategy II</u> 12,225*
Less 9.0% emission reduction expected from regional or state-wide inspection and maintenance program	<u>1,100</u> due to I & M program 11,125*
Less 8.2% emission reduction expected from regional or state-wide retrofit program (oxidizing catalytic converters attached to 1968-1974 model year vehicles)	<u>912</u> due to retrofit
Net expected CO emission rate for Zone 1	10,213* kg/day

It will be seen that this strategy package reduces CO emissions to slightly below the level required to attain the 9.0 ppm eight-hour average CO level.

Similarly, it will be seen from Table Pitt.2 that Inspection & Maintenance and Retrofit reduce hydrocarbon emissions below the levels necessary to attain oxidant standards by 1977.

*Computational procedures lead to small differences between these figures and those shown in Table Pitt.1.

TABLE PITT.1
TOTAL CARBON MONOXIDE EMISSIONS IN KG/DAY AND EXPECTED MAXIMUM EIGHT-HOUR AVERAGE CO CONCENTRATIONS
IN PPM FOR PITTSBURGH, ZONE 1 (CBD)

YEAR	NON-VEHICULAR EMISSIONS	NO STRATEGIES VEHICLE EMISSIONS	WITH STRATEGIES 1 AND 2 VEHICULAR EMISSION	WITH I & M VEHICULAR EMISSION	WITH RETROFIT VEHICULAR EMISSION	WITH STRATEGIES TOTAL EMISSIONS	CONCEN- TRATION
1970		29,530	----				
1971		28,541	----			29,311	21.3
1972	2,200	27,111	21.3			26,594	19.3
1973	1,940	24,654	19.3			23,799	17.3
1974	1,680	22,343	17.5			20,329	14.8
1975	1,419	19,538	15.2			15,183	11.0
1976	1,419	15,992	12.7	14,352	13,764	11,616	8.4
1977	1,419	13,120	10.6	11,108	10,197	9,793	7.1
1978	1,469	10,698	8.8	9,068	8,324	8,454	6.1
1979	1,520	8,897	7.6	7,553	6,934	7,195	5.2
1980	1,573	7,199	6.4	6,124	5,622	6,304	4.6
1981	1,628	5,974	5.5	5,094	4,676	5,826	4.2
1982	1,685	5,278	5.1	4,511	4,141	5,536	4.0
1983	1,744	4,825	4.8	4,131	3,792	5,307	3.9
1984	1,805	4,447	4.5	3,815	3,502	5,338	3.9
1985	1,868	4,404	4.6	3,780	3,470	5,331	3.9
1986	1,933	4,309	4.5	3,701	3,398		

TABLE PITT.2

TOTAL HC EMISSIONS IN KG/DAY AND EXPECTED MAXIMUM ONE-HOUR AVERAGE OXIDANT CONCENTRATIONS
IN PPM FOR ALLEGHENY COUNTY

YEAR	NON-VEHICULAR EMISSIONS	WITHOUT STRATEGIES		OX CONC.	VEHICULAR EMISSIONS		WITH STRATEGIES	
		VEHICULAR EMISSIONS	TOTAL EMISSIONS		WITH I & M	WITH RETROFIT	TOTAL EMISSIONS	OX CONC.
1970		124,141						
1971		112,553						
1972	28,820	99,500	128,320	.165			128,320	.165
1973	25,851	88,603	114,454	.153			114,454	.153
1974	22,883	78,588	101,471	.140			101,471	.140
1975	19,915	66,803	86,718	.122			86,718	.122
1976	17,425	53,822	71,247	.101	50,915	48,828	66,253	.095
1977	14,936	44,593	59,529	.084	39,777	36,516	51,452	<.080
1978	15,459	37,793	53,252	<.080	33,712	30,947	46,406	
1979	16,000	31,995	47,995		28,539	26,199	42,199	
1980	16,560	27,124	43,684		24,195	22,211	38,771	
1981	17,140	24,381	41,521		21,748	19,964	37,104	
1982	17,740	22,505	40,245		20,075	18,429	36,169	
1983	18,361	20,817	39,178		18,569	17,046	35,407	
1984	19,004	20,374	39,378		18,173	16,683	35,687	
1985	19,669	20,282	39,951		18,092	16,608	36,277	
1986	20,357	20,020	40,387	<.080	17,867	16,402	36,759	<.080

3.11 SUMMARY AND CONCLUSIONS - ST. PAUL/MINNEAPOLIS MINNESOTA

3.11.1 Air Quality and Emissions

The one-hour average oxidant air quality standard will be attained by 1977 in the Minneapolis-St. Paul Metropolitan Areas, including the two CBD's as demonstrated in Tables Minn.1 and Minn.2. This standard will be attained as a result of the hydrocarbon emission reductions obtained from the FMVECP. In determining that the oxidant standard would be attained by 1977, GCA took the conservative approach of not considering the application of non-vehicular control strategies for hydrocarbons. With the application of such non-vehicular control strategies, attaining the oxidant standard by 1977 would be further assured.

Carbon Monoxide Air Quality Band Emissions

Eight-hour average CO air quality standards will be attained by 1977 in the Minneapolis-St. Paul, Metropolitan Area with the exception of the Minneapolis CBD and St. Paul CBD with the CO emission reductions obtained from the FMVECP. Tables Minn.3 and Minn.4 summarize the emissions and air quality in the two CBD's with and without the application of the recommended control strategies.

3.11.2 Control Strategies

The following transportation control strategies are recommended and their impact is summarized in Tables Minn.3 and Minn.4.

Minneapolis CBD

- Strategy 1: Fringe parking combined with people mover system estimated to reduce 1977 light-duty VMT's by 8 percent.
- Strategy 2: Traffic surveillance and control estimated to increase average speed in Minneapolis CBD from 14 mph to 20 mph by 1977.

Table Minn.1. SUMMARY OF OXIDANT AIR QUALITY AND
HYDROCARBON EMISSIONS IN MINNEAPOLIS CBD

A. Area = 2.2 sq. miles

B. Hydrocarbon Emissions (kg/12 hrs) and oxidant levels (ppm)

	1971	1977 Without Strategy
Vehicle Emissions	3,560	1,720
Non-Vehicular Emissions	1,540	1,840
Total Emissions	5,100	3,560
Oxidant level (1-hr average)	0.114	< 0.08

Table Minn.2. SUMMARY OF OXIDANT AND AIR QUALITY
AND HYDROCARBON EMISSIONS IN ST. PAUL CBD

A. Area = 0.8 sq. miles

B. Hydrocarbon Emissions (kg/12 hrs) and oxidant levels (ppm)

	1971	1977 Without Strategy
Vehicle Emissions	1,290	620
Non-Vehicular Emissions	560	670
Total Emissions	1,850	1,290
Oxidant level (1-hr average)	0.114	< 0.08

Table Minn. 3. SUMMARY OF CARBON MONOXIDE AIR QUALITY AND EMISSIONS
IN MINNEAPOLIS CBD

A. Area = 2.2 sq. miles

B. CO emissions (kg/12 hrs) and air quality levels (ppm)

	1971	1977 Without Strategy	1977 With Strategy #1 Only	1977 With Strategies #1 & #2	Without Strategies 1978	1979
Vehicle Emissions	27,960	14,116	13,316	10,016	11,912	10,008
Non-Vehicular Emissions	240	284	284	284	288	292
Total Emissions	28,200	14,400	13,600	10,300	12,200	10,300
CO level (8-hr average)	18.9	9.7	9.1	6.9	8.2	6.9

Table Minn.4. SUMMARY OF CARBON MONOXIDE AIR QUALITY AND EMISSIONS
IN ST. PAUL CBD

A. Area = 0.8 sq. miles

B. CO emissions (kg/12 hrs) and air quality (ppm)

	1971	1977				Without Strategies	
		Without Strategy	With Strategy #1 Only	With Strategy #1 & #2	With Strategies	1978	1979
Vehicle Emissions	10,013	5,097	4,697	3,597		4,295	3,594
Non-Vehicular Emissions	87	103	103	103		105	105
Total Emissions	10,100	5,200	4,800	3,700		4,400	3,700
CO level (8-hr average)	18.6	9.5	8.8	6.8		8.1	6.8

St. Paul CBD

Strategy 1: Fringe parking combined with shuttle bus service estimated to reduce 1977 light-duty VMT's by 10 percent.

Strategy 2: Traffic signal system estimated to increase average speed in St. Paul CBD from 12 mph to 18 mph by 1977.

3.12 SUMMARY AND CONCLUSIONS - SALT LAKE CITY, UTAH

The analysis described in the City Report indicates a need for transportation control strategies to reduce CO emissions within Salt Lake City's central business district if the national eight-hour average standard for CO concentration is to be attained by 1977. On the other hand, the available data indicate that the oxidant standard and the one-hour average CO standard will be attained throughout the urban area by means of the FMVECP alone.

After evaluating the probable effectiveness and feasibility of a large number of possible controls, the recommended strategy selected is Traffic Flow Improvement, to be achieved principally by means of a computerized traffic signal system (TOPICS Improvement Project No. 1). Current estimates indicate that the standards may be met in 1977 by implementation of this strategy. However, it is recommended that consideration be given to "back-up" strategies, including mass transit development, in the event that additional controls prove necessary. It is also recommended that the role of the automobile -- in particular, parking in the downtown area -- be carefully re-evaluated.

Table SLC.1 summarizes the magnitude of the problem and the effect of the computerized traffic signal system on CO emissions in the area of principal concern. At the request of EPA, projections were made from two baseline years, 1970 and 1971. It is emphasized again that the air quality estimates are "best estimates" based on available data and the proportional model. Also, experience shows that considerable variation in the maximum (or second highest) eight-hour concentration will be experienced at a given sampling location from year to year even under relatively constant emission rates. Finally, in addition to the temporal variation in air quality at a given station, substantial spatial variations are to be expected within the CBD. The predicted concentrations are presented in tenths of a part per million simply to indicate the anticipated overall trend in air quality.

The analysis of hydrocarbon emissions indicated that emissions from motor vehicles will decrease by 52 percent between 1971 and 1977 as a result of the FMVECP and that total emissions of hydrocarbons in a 14 square mile central zone of Salt Lake City will be about 30 percent below the allowable level in 1977.

3.13 SUMMARY AND CONCLUSIONS - SEATTLE, WASHINGTON

The analysis described in the City Report indicates a need for transportation control strategies to reduce CO emissions within Seattle's central business district if the national eight-hour average standard for CO concentration is to be attained by 1977. On the other hand, the available data indicate that the oxidant standard and the one-hour average CO standard will be met throughout the urban area by means of the FMVECP alone. This assessment is based on recently acquired data and is somewhat at variance with the assessment made in the Implementation Plan which was based upon air quality measurements made in 1970 near a major freeway and indicated that both CO and oxidant problems would still be present in Seattle in 1977 unless transportation control strategies were adopted.

After evaluating a large number of possible controls, three strategies are recommended for implementation. They are:

1. METRO Transit development
2. Fringe parking with Personalized Rapid Transit (PRT)
3. Improved downtown signal system

These three strategies together provide about one-third of the reduction in emissions required to meet the national eight-hour standard. The remaining reduction can be achieved through strategies which directly limit emissions from operating vehicles, such as retrofit, gaseous conversion of fleet vehicles and inspection, or by strategies which eliminate older vehicles from the CBD. The single strategy of excluding all pre-controlled vehicles from the CBD, in conjunction with Strategies 1, 2, and 3 above, is judged to be just sufficient. A margin of safety can be introduced by means of additional strategies, if desired. The general use of retrofit systems with the requisite annual inspection and maintenance program, results in reductions considerably greater than required, and is not looked upon with favor by the State of Washington at the present time.

Table Sea.1 summarizes the CO problem and the cumulative effects of Strategies 1, 2, and 3 plus the exclusion of pre-controlled vehicles. It is emphasized again that the air quality estimates are "best estimates" based on available data and the proportional model. Also, experience shows that considerable variation in the maximum (or second highest) eight-hour concentration will be experienced at a given sampling location from year to year even under relatively constant emission rates. Finally, in addition to the temporal variation in air quality at a given station, substantial spatial variations are to be expected within the CBD. The predicted concentrations are presented in tenths of a part per million simply to indicate the anticipated overall trend in air quality.

The analysis of hydrocarbon emissions indicated that emissions from motor vehicles will decrease by 51 percent between 1971 and 1977 as a result of the FMVECP and that total emissions of hydrocarbons in the 23 square mile central zone of Seattle will be 16 percent below the allowable level in 1977. Use of the oxidant data used in the Implementation Plan, however, indicate the need for an additional reduction in vehicular emissions of 6.6 percent.

Table Sea.1. SUMMARY EMISSION AND CO AIR QUALITY DATA FOR SEATTLE CBD

	Without Strategies			With Strategies (1977)			
	1971	1977	1978	1979	METRO + PRT +	Sig.Sys. +	Exclusion
a) Emission Densities (kg/8 hr/mi ²)							
Vehicular	14,301	8,175	6,951	6,001	8,032	7,875	7,579
Non-vehicular	292	292	292	292	292	292	292
Total	14,593	8,467	7,243	6,293	8,324	8,167	7,871
b) Air Quality (8-hr average in ppm)							
Observed (2nd highest)	20	11.6	9.9	8.6	11.4	11.2	10.8
Estimated							9.0
c) Maximum Allowable Emission Level (kg/8 hr/mi ²)							
	<u>Total</u>	<u>Non-Vehicular</u>	<u>Vehicular</u>				
	6,567	292	6,275				
d) Reduction in Vehicular Emissions from 1971 levels							
From Federal Motor Vehicle Control Program							Percent
Additional Required by Transportation Control Strategies							43
							13
d) Reduction in Vehicular Emissions from 1977 "no strategy" level							
Required by Transportation Control Strategies							Percent
							23

Table Sea.1. SUMMARY EMISSION AND CO AIR QUALITY DATA FOR SEATTLE CBD

	Without Strategies			With Strategies (1977)			
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Estimated							9.0
c) Maximum Allowable Emission Level (kg/8 hr/mi ²)							
	<u>Total</u>	<u>Non-Vehicular</u>	<u>Vehicular</u>				
	6,567	292	6,275				
d) Reduction in Vehicular Emissions from 1971 levels							
From Federal Motor Vehicle Control Program							Percent
Additional Required by Transportation Control Strategies							43
							13
e) Reduction in Vehicular Emissions from 1977 "no strategy" level							
							Percent
Required by Transportation Control Strategies							23

3.14 SUMMARY AND CONCLUSIONS - SPOKANE, WASHINGTON

The analysis described in the City Report indicates a need for transportation control strategies to reduce CO emissions within Spokane's central business district if the national eight-hour average standard for CO concentration is to be attained by 1977. On the other hand, the available data indicate that the oxidant standard and the one-hour average CO standard will be attained throughout the urban area by means of the FMVECP alone.

After evaluating a large number of possible controls, three strategies are recommended for implementation. They are:

1. A computer controlled signal system in downtown Spokane
2. Transit improvement
3. Pedestrian separations (second level sidewalks)

These three strategies together provide about half the reduction in emissions required to meet the national eight-hour standard. The remaining reduction can be achieved through strategies which directly limit emissions from operating vehicles, such as retrofit, gaseous conversion of fleet vehicles and inspection, or by strategies which eliminate older vehicles from the CBD. The single strategy of excluding all pre-controlled vehicles from the CBD, in conjunction with Strategies 1, 2, and 3 above is judged to be more than sufficient to bring about the necessary reduction in emissions. The necessary additional reduction can also be attained by the use of the "air bleed to intake manifold" retrofit device on pre-1968 vehicles.

Table Spo.1 summarizes the CO problem and the cumulative effects of Strategies 1, 2, and 3 plus the exclusion of pre-controlled, light-duty vehicles. It is emphasized again that the air quality estimates are "best estimates" based on available data and the proportional model. Also, experience shows that considerable variation in the maximum (or second highest) eight-hour concentration will be experienced at a given sampling location from year to year even under relatively constant emission

Table Spo.1. SUMMARY EMISSIONS AND CO AIR QUALITY DATA FOR
SPOKANE CBD

	Without Strategies			With Strategies (1977)			Exclu- sion
	1971	1977	1978	1979	Sig. Sys. + Imp.	Fed. Sep.	
a) Emission Densities (kg/8 hr/mi ²)							
Vehicular	7932	4751	4066	3482	4454	4351	3,543
Non-vehicular	162	162	162	162	162	162	162
Total	8094	4913	4228	3644	4616	4513	3,705
b) Air Quality (8-hr average in ppm)							
Observed (2nd highest)	18	10.9	9.4	8.1	10.3	10.0	8.2
Estimated							
c) Maximum Allowable Emission Level (kg/8 hr/mi ²)							
Total	4047						
Non-Vehicular	162						
Vehicular					3885		
d) Reduction in Vehicular Emissions from 1971 levels							
Percent							
From Federal Motor Vehicle Control Program					40		
Additional Required by Transportation Control Strategies					11		
e) Reduction in Vehicular Emissions from 1977 "no strategy" level							
Percent							
Required by Transportation Control Strategies					18		

rates. Finally, in addition to the temporal variation in air quality at a given station, substantial spatial variations are to be expected within the CBD. The predicted concentrations are presented in tenths of a part per million simply to indicate the anticipated overall trend in air quality.

APPENDIX A
ATTITUDINAL SURVEY

The following represents the results of a questionnaire distributed in seven metropolitan areas for the purpose of gaining some insight to public attitudes towards air pollution and transportation control measures designed to reduce air pollution. The survey was conducted with the assistance of a professional market research group* which maintains standing panels of households in each major metropolitan area; each representing a broad cross-section of households in the given area. The seven metropolitan areas surveyed include:

- Dayton, Ohio
- Denver, Colorado
- Houston, Texas
- Los Angeles, California
- New York, New York
- Philadelphia, Pennsylvania
- Phoenix, Arizona

*Market Facts, Inc., 100 South Wacker Drive, Chicago, Illinois 60606

MAJOR FINDINGS

A. Auto Air Pollution

1. About 85-95 percent of all respondents in all cities feel auto air pollution is a serious or very serious nationwide problem. This feeling is highest in Denver (94%) and lowest in Houston (85%).
2. Respondents in all seven cities feel that auto air pollution is a more serious problem nationwide than it is locally.
3. A law, requiring auto emission control equipment of all pre 1975 cars is much more acceptable at a government subsidized cost of \$50 than a non-government subsidized cost of \$200. Regardless of the cost, this law is viewed more favorably by respondents in New York and Philadelphia. A law requiring inspection of this equipment is also viewed more favorably by respondents in New York and Philadelphia. Respondents in all cities feel the cost of this inspection should be under \$9.00.
4. In all cities the two most acceptable proposals for controlling auto air pollution are "prohibit traffic/parking in central business districts" and "create car pool/bus only lanes on major thoroughfares". The two most unacceptable are "gasoline rationing" and "\$500 registration fee for each auto".
5. Interest in car pools as a means of reducing auto air pollution is about 40-50 percent of the respondents in each city; but the prospect of joining one or organizing one is viewed as difficult by 75-85 percent of non-car pool riders.

6. The prohibition of parking, loading and unloading on busy streets is rated as being very effective or somewhat effective by respondents in New York (90%) and Dayton (98%) in reducing traffic congestion. Respondents in the remaining cities feel that improving the timing of traffic signals would be the best way to reduce traffic congestion. All cities agree that widening major streets at intersections would be the least effective way of reducing traffic congestion.

B. Transportation Usage

1. Public transportation usage is highest in New York (229 trips per household per year) and Philadelphia (135). The remaining cities are much lower in usage (under 40).
2. Reasons for public transportation usage vary by city. Overall it is used in New York and Philadelphia because it's cheaper and faster. In Denver it's used because it's cheaper and less congested. In Los Angeles it's used out of necessity (no car available or no driver's license). Reasons for usage in the other cities vary.
3. Reasons for auto usage are the same in all cities - faster, more flexible, more available.
4. The most effective proposals for encouraging usage of public transportation facilities tend to be similar to the reasons people travel by auto - more frequent service, faster travel, more conveniently located stops and stations and lower fares. This is true for almost all seven cities.
5. In all cities there is substantial reluctance (66% or higher) to disposing of any car or cars even if public transportation was improved.

DETAILED FINDINGS - AUTO AIR POLLUTION

1. SERIOUSNESS OF AUTO AIR POLLUTION

Feelings that auto air pollution is a "serious or very serious" nationwide problem were highest in Denver (94%) and lowest in Houston (84%).

Feelings that auto air pollution is a "serious or very serious" problem in their city were highest in Los Angeles (81%) and lowest in Dayton (45%).

In all seven cities respondents felt that auto air pollution is more of a serious or very serious problem in the nation than in their particular city.

		This Percent of Respondents In These Cities:						
<u>Said Auto Air Pollution Nation-wide Is:</u>		<u>New York</u>	<u>Phila- delphia</u>	<u>Day- ton</u>	<u>Phoe- nix</u>	<u>Hous- ton</u>	<u>Den- ver</u>	<u>Los Angeles</u>
		<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>
Very serious		43	46	41	56	49	55	41
Serious		42	41	44	33	35	39	48
Slightly serious		14	12	15	11	15	5	9
No problem		1	1	-	-	1	1	2
<u>Said Auto Air Pollution In Their City Is:</u>								
Very serious		49	31	13	27	51	39	55
Serious		27	40	32	33	25	30	26
Slightly serious		17	25	40	36	17	24	15
No problem		7	4	15	4	7	7	4
(Total Number of Respondents)		(164)	(178)	(99)	(178)	(163)	(204)	(193)

2. REGULATION OF AUTO AIR POLLUTION THROUGH EMISSION CONTROL EQUIPMENT

a. By Law Requiring Equipment on All Autos

Respondents were asked how they would feel about a possible law requiring them in 1975 to put emission control equipment on cars manufactured prior to 1975 at both a non government subsidized cost of \$200 per car or a government subsidized cost of \$50 per car. In all cities the subsidized cost was preferred over the non subsidized cost by a margin of two to one.

Regardless of the cost to the owner, respondents in New York and Philadelphia were more in favor of the law than respondents in other cities.

Feel This Way About
A Law in 1975 Requiring
A Car Owner to Put
Emission Control
Equipment on Their
Pre 1975 Model Cars:

This Percent of Respondents In These Cities:

New York	Phila- delphia	Day- ton	Phoe- nix	Hous- ton	Den- ver	Los Angeles
<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>

At Cost of \$200 Per Car:

Very much in favor	14	12	11	13	9	10	11
Somewhat in favor	28	30	23	20	25	21	22
Somewhat against	19	18	25	17	22	15	13
Very much against	39	40	41	50	44	54	54

At Cost of \$50 Per Car:

Very much in favor	65	62	46	49	45	50	43
Somewhat in favor	19	23	22	20	26	24	23
Somewhat against	8	6	12	12	9	11	15
Very much against	8	9	20	19	20	15	19

(Total Number
Respondents)

(164) (178) (99) (178) (163) (204) (193)

b. By Law Requiring Inspection of Equipment

Respondents were also asked how they would feel about a law requiring periodic inspection of emission control systems, how much they would be willing to pay for the inspection and where the inspection should be made. The majority of respondents in all cities were in favor of the law (about 90% in favor).

The mean amount respondents would pay for inspection is \$6.93. Respondents in Dayton would pay the most (\$8.90) and Denver respondents the least (\$4.58).

Respondents in all cities except Houston and Denver prefer to have their car inspected at state-operated inspection center. Houston and Denver respondents prefer their local service stations or garages.

<u>Feel This Way About Law Requiring Inspection Of Emission Control Equipment:</u>	<u>This Percent of Respondents In These Cities:</u>						
	<u>New York</u>	<u>Phila- delphia</u>	<u>Day- ton</u>	<u>Phoe- nix</u>	<u>Hous- ton</u>	<u>Den- ver</u>	<u>Los Angeles</u>
	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>
Very much in favor	72	61	42	54	57	59	48
Somewhat in favor	19	31	36	26	25	26	32
Somewhat against	4	4	11	11	10	9	8
Very much against	5	4	11	9	8	6	12
<u>Would Pay This Mean Amount For Inspection:</u>	<u>\$</u>	<u>\$</u>	<u>\$</u>	<u>\$</u>	<u>\$</u>	<u>\$</u>	<u>\$</u>
	7.80	7.02	8.90	6.89	5.48	4.58	7.87
<u>Would Prefer to Have Car Inspected At:</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>
State operated center	45	62	43	50	42	36	41
City operated center	10	3	17	14	9	8	14
Local service station/ garage	39	32	32	32	46	52	39
Other	6	3	8	4	3	4	6
(Total Number of Respondents)	(164)	(178)	(99)	(178)	(163)	(204)	(193)

3. PROPOSALS TO CONTROL AUTO AIR POLLUTION

Respondents were asked to evaluate several proposals aimed at reducing the amount of auto air pollution in their cities. Each proposal was evaluated in terms of the following scale:

Very Acceptable	(+2)
Somewhat Acceptable	(+1)
Neither Acceptable or Unacceptable	(0)
Somewhat Unacceptable	(-1)
Very Unacceptable	(-2)

A mean rating for each proposal was calculated using the weights indicated above in the parentheses. A positive mean rating means the proposal is acceptable. A negative rating indicated unacceptability of the proposal. A rating close to zero indicates indifference to the proposal.

Based on the mean ratings, in all seven cities the two most acceptable proposals were to "create bus only and car pool only lanes on major thoroughfares" and to "prohibit traffic and parking in central business districts". The two least acceptable proposals were to "have a very high (\$500) registration fee per auto owned" and to "ration gasoline".

It is worth noting that the highest rating received by any proposal in any city was .9 and the lowest in any city was -1.9. In short none of the proposals were rated as high as "somewhat acceptable" in any city while five of the proposals were rated lower than "somewhat unacceptable" in all cities.

<u>Gave These Mean Ratings To These Proposals For Reducing Auto Air Pollution:</u>	<u>Respondents In These Cities:</u>						
	<u>New York</u>	<u>Phila- delphia</u>	<u>Day- ton</u>	<u>Phoe- nix</u>	<u>Hous- ton</u>	<u>Den- ver</u>	<u>Los Angeles</u>
Gasoline rationing	-1.6	-1.5	-1.4	-1.5	-1.7	-1.4	-1.5
\$500 registration fee for each auto	-1.7	-1.8	-1.8	-1.8	-1.9	-1.8	-1.8
\$500 registration fee for 2nd, 3rd, etc., auto	-1.1	-1.3	-1.2	-1.2	-1.6	-1.2	-1.4
Prohibit traffic/parking in central districts	.6	.6	.2	-.1	.2	.6	-.1
Tax on all day parking in central business districts	.2	-.2	-.3	-.3	-.4	-.1	-.5
Tax on parking in central business districts regard- less of time parked	-.3	-.8	-.7	-.9	-.9	-.7	-1.0
Tolls on exit ramps of major thoroughfares	-1.2	-1.2	-1.3	-1.2	-1.4	-1.3	-1.4
Tolls on exit ramps of major thoroughfares in times of heavy traffic	-1.1	-1.2	-1.2	-1.2	-1.3	-1.2	-1.3
Control of auto usage through special plates/ stickers	-.2	-.4	-.7	-.6	-.9	-.3	-.4
Create "bus/car pool only" lanes on major thoroughfares	.8	.6	.5	.5	.9	.5	.6
(Total Number of Respondents)	(164)	(178)	(99)	(178)	(163)	(204)	(193)

The mean ratings on the previous table are deceptive to the extent that the degree of acceptability or unacceptability amongst the proposals is not readily perceptible. Respondents were asked to record by letter which proposal would be the most acceptable or unacceptable to them. The following two tables show on a percentage basis the degree of acceptability or unacceptability of each proposal. These tables mirror the mean ratings in pointing out which two proposals are the most acceptable and least acceptable.

It is worth noting that specific proposals in all cities have "most acceptable" and "most unacceptable" shares that are low. These low shares are no reflection on the effectiveness of the proposal if implemented; but show a lack of enthusiasm (either positive or negative) for the proposal. In short, these proposals should not be cast aside without further consideration because of low "most acceptable" shares.

<u>Said These Proposals Were Most Acceptable:*</u>	<u>This Percent of Respondents In These Cities:</u>						
	<u>New York</u>	<u>Phila- delphia</u>	<u>Day- ton</u>	<u>Phoe- nix</u>	<u>Hous- ton</u>	<u>Den- ver</u>	<u>Los Angeles</u>
	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>
Gasoline rationing	2	2	7	2	1	4	4
\$500 registration fee for each auto	1	1	-	2	1	1	3
\$500 registration fee for 2nd, 3rd, etc., auto	5	6	4	6	3	3	6
Prohibit traffic/parking in central business districts	36	38	33	24	25	35	18
Tax on all day parking in central business districts	9	9	10	13	7	11	7
Tax on parking in central business districts regard- less of time parked	5	2	4	2	2	5	1
Tolls on exit ramps of major thoroughfares	1	3	6	4	5	4	3
Tolls on exit ramps of major thoroughfares in times of heavy traffic	1	-	2	2	1	1	1
Control of auto usage through special plates/ stickers	18	14	13	12	9	19	20
Create "bus/car pool only" lanes on major thoroughfares	41	30	36	45	56	34	48
(Total Number of Respondents)	(164)	(178)	(99)	(178)	(163)	(204)	(193)

* Percentages to over 100% due to multiple answers.

Said These Proposals Were Most Unacceptable:*	This Percent of Respondents In These Cities:						
	New York	Phila- delphia	Day- ton	Phoe- nix	Hous- ton	Den- ver	Los Angeles
	%	%	%	%	%	%	%
Gasoline rationing	39	30	27	33	44	33	30
\$500 registration fee for each auto	50	61	59	55	50	54	56
\$500 registration fee for 2nd, 3rd, etc., auto	7	6	6	9	10	10	10
Prohibit traffic /parking in central business districts	2	1	1	3	2	2	2
Tax on all day parking in central business districts	3	3	5	3	2	3	5
Tax on parking in central business districts regard- less of time parked	6	3	3	5	4	3	4
Tolls on exit ramps of major thoroughfares	8	5	9	8	7	11	8
Tolls on exit ramps of major thoroughfares in times of heavy traffic	3	3	2	4	4	5	5
Control of auto usage through special plates / stickers	3	4	5	2	6	4	5
Create "bus /car pool only" lanes on major thoroughfares	-	1	2	1	2	2	2
All	3	2	2	3	4	1	5
(Total Number of Respondents)	(164)	(178)	(99)	(178)	(163)	(204)	(193)

* Percentages to over 100% due to multiple answers.

a. Travelling to and From Work In a Car Pool

Respondents in all seven cities were also asked how they would feel about travelling to and from work in a car pool and, if car pools became necessary, how difficult or easy would it be for them to join or organize one.

Interest on car pools among respondents was highest in Dayton and Denver (about 50%) - with respondents in all the other cities are about equal in their interest in them (about 40%).

Present usage of car pools ranges from four to nine percent. Non auto travel to and from work is highest in New York (28%) and lowest in Houston (6%). About seventy-five to eighty-five percent of all respondents who go to work by auto, feel it would be difficult to join or organize a car pool.

<u>Said They Would Be This Interested In A Car Pool:</u>	<u>This Percent of Respondents In These Cities:</u>						
	<u>New York</u>	<u>Phila- delphia</u>	<u>Day- ton</u>	<u>Phoe- nix</u>	<u>Hous- ton</u>	<u>Den- ver</u>	<u>Los Angeles</u>
	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>
Very interested	18	14	12	17	13	19	18
Somewhat interested	21	26	35	25	24	31	22
Not at all interested	29	39	35	38	48	33	44
Already in car pool	4	6	7	5	9	6	4
Do not travel by car to and from work	28	15	11	15	6	11	12
<u>Said Getting Into A Car Pool Would Be:*</u>							
Difficult	83	84	80	79	74	74	86
Easy	17	16	20	21	26	26	14
(Total Number of Respondents)	(164)	(178)	(99)	(178)	(163)	(204)	(193)

* Percentaged over respondents presently not in a car pool.

4. PROPOSALS TO REDUCE TRAFFIC CONGESTION

One of the main causes of auto air pollution is traffic congestion and/or stop and go driving. Respondents were asked to consider several proposals aimed at reducing traffic congestion. Of the ten proposals considered, respondents in all cities except New York and Dayton felt that improving the timing of traffic signals would be the most effective method of reducing traffic congestion. Respondents in New York and Dayton felt the prohibition of parking, loading, and unloading on busy streets would be the most effective. Respondents in all cities agreed that widening major streets at intersections would be the least effective method of reducing traffic congestion.

In each city most proposals were rated very or somewhat effective by seventy percent of the respondents. These generally high ratings mean that all of the proposals are felt by the majority respondents to have some amount of effectiveness in reducing traffic congestion.

Said These Proposals
Would Be "Very" or
"Somewhat" Effective
In Reducing Traffic
Congestions:

This Percent of Respondents In These Cities:

	New York	Phila- delphia	Day- ton	Phoe- nix	Hous- ton	Den- ver	Los Angeles
	%	%	%	%	%	%	%
Prohibit parking, loading unloading on busy streets	90	94	98	90	92	92	89
Increase number of one- way streets	71	68	66	84	79	82	73
Establish reversible lanes for rush hours	72	74	66	77	58	63	69
Prohibit turns at busy intersections for rush hours	81	83	85	89	85	73	85
Widen major streets	81	83	81	88	88	78	80
Widen major streets at intersections	63	54	61	62	53	50	48
Provide pedestrian over passes/under- passes	86	85	95	77	85	81	82
Improve timing of traffic signals	86	97	95	94	95	95	97
Increase number and frequency of traffic reports	69	71	71	67	74	73	70
Create "bus/car pool only" lanes	81	82	77	73	87	78	78
(Total Number of Respondents)	(164)	(178)	(99)	(178)	(163)	(204)	(193)

One additional proposal for reducing traffic congestion was presented to respondents. This proposal was to have working hours staggered throughout the day for the purpose of reducing large traffic flows during specific times of the day - rush hours.

The majority of respondents in all cities had favorable attitudes towards this proposal. Favorable attitudes towards this proposal were highest in New York and Houston (about 70% in each). Attitudes opposed to this proposal were highest in Dayton.

<u>Felt This Way About Staggered Working Hours:</u>	<u>This Percent of Respondents In These Cities:</u>						
	<u>New York</u>	<u>Phila- delphia</u>	<u>Day- ton</u>	<u>Phoe- nix</u>	<u>Hous- ton</u>	<u>Den- ver</u>	<u>Los Angeles</u>
	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>	<u>%</u>
In favor of idea	70	68	59	68	71	64	67
Indifferent to idea	10	15	16	18	10	16	13
Opposed to idea	20	17	25	14	19	20	20
(Total Number of Respondents)	(164)	(178)	(99)	(178)	(163)	(204)	(193)

DETAILED FINDINGS - TRANSPORTATION USAGE
1. USAGE OF PUBLIC TRANSPORTATION

Respondents (female household heads) in all cities were requested to obtain information from other household members in addition to themselves regarding usage and reasons for usage of auto and public (bus, subway, commuter train) transportation. One of the questions answered by all household members (husband, wife, children over 16 years old) pertained to usage of public transportation. The responses were recorded on the following scale and weighted to obtain a mean travel frequency per year:

<u>Scale</u>	<u>Weight</u>
Three or more times a week	208
One to two times a week	78
Once a month	12
Once every three months	4
Never	0
No Household member	(Not Applicable)

Households in New York and Philadelphia use public transportation far more frequently than households in the other cities. An average household in New York uses public transportation 229 times per year. In Philadelphia this figure is 135 times. A typical household in Phoenix uses public transportation an average of 10 times per year; Houston and Los Angeles less than 30 times per year and Dayton and Denver less than 40 times.

In all cities except Phoenix, children (over 16 years old) are the most frequent users of public transportation. In all cities except New York, the wife tends to use public transportation more often than the husband.

<u>Public Transportation Is Used By These Household Members:</u>	<u>Mean Number of Times Per Year In These Cities:</u>						
	<u>New York</u>	<u>Phila- delphia</u>	<u>Day- ton</u>	<u>Phoe- nix</u>	<u>Hous- ton</u>	<u>Den- ver</u>	<u>Los Angeles</u>
Husband	73	30	4	1	4	5	3
Wife	61	36	9	6	4	8	7
Children (over 16 years old)	95	69	25	3	20	21	17
Total Per Year* Per Household	229	135	38	10	28	34	27
(Total Number of Respondents)	(164)	(178)	(99)	(178)	(163)	(204)	(193)

* Wording of question is such that "times" is interpreted to be a round trip not a one-way trip.

2. REASONS FOR USAGE OF PUBLIC TRANSPORTATION

Household members indicating usage of public transportation were asked to rank in order of importance several prelisted reasons for using public transportation. Their most important reason was ranked "1", next important "2" etc. Means were calculated on the basis of the numerical rank. The following three tables show the mean ranking given each reason by the various household members (husband, wife, children over 16 years old). Eligible household members who did not rank a reason were excluded from the mean scores.

Although the number of household members eligible to answer is very small in some cities, some generalizations can be made about reasons for using public transportation. In New York husbands and wives use public transportation because it is cheap and fast. In Philadelphia husbands use it for the same reasons as New York husbands, but Philadelphia wives use public transportation because they don't have drivers licenses or because its more available. Husbands and wives in Dayton, Phoenix and Houston tend to vary their reasons for usage. Denver husbands and wives use it because its cheaper and less congested. "No drivers license" and "no car available" tend to be the reasons for public transportation usage by both husbands and wives in Los Angeles. Children in all cities use public transportation because its cheaper, faster, and more available than other forms of transportation.

<u>Gave This Mean Rating to These Reasons for Using Public Transportation: *</u>	<u>Husbands in These Cities:</u>						
	<u>New York</u>	<u>Phila- delphia</u>	<u>Day- ton</u>	<u>Phoe- nix</u>	<u>Hous- ton</u>	<u>Den- ver</u>	<u>Los Angeles</u>
Cheaper	<u>2.9</u>	<u>2.7</u>	<u>4.0</u>	4.0	3.3	<u>1.8</u>	2.7
Faster	<u>2.8</u>	<u>3.0</u>	<u>2.5</u>	<u>4.0</u>	5.7	4.0	7.0
More comfortable	5.3	5.2	<u>4.0</u>	<u>3.3</u>	6.5	4.6	7.5
Safer for passenger	5.4	5.3	<u>2.5</u>	7.0	5.5	3.0	8.0
Less congested	4.6	3.4	<u>1.1</u>	7.0	8.0	<u>2.7</u>	6.0
More available	3.4	4.1	7.5	<u>3.0</u>	3.7	6.0	5.5
More flexible	5.2	7.5	8.5	5.5	<u>2.5</u>	5.1	6.0
More relaxing	4.4	4.0	3.8	6.3	<u>2.0</u>	4.0	3.3
No drivers license	9.0	6.7	6.0	6.0	-	10.0	<u>1.0</u>
Car not available	5.3	4.6	5.7	3.7	3.2	4.0	<u>1.4</u>
(Total Number of Eligible Husbands)	(76)	(54)	(8)	(6)	(6)	(18)	(10)

* The higher the number, the less important the reason.

<u>Gave This Mean Rating to These Reasons for Using Public Transportation: *</u>	<u>Wives in These Cities:</u>						
	<u>New York</u>	<u>Phila- delphia</u>	<u>Day- ton</u>	<u>Phoe- nix</u>	<u>Hous- ton</u>	<u>Den- ver</u>	<u>Los Angeles</u>
Cheaper	<u>2.8</u>	4.2	3.9	<u>3.9</u>	3.3	<u>2.1</u>	3.1
Faster	<u>2.8</u>	3.8	4.5	4.0	6.0	4.3	7.2
More comfortable	5.9	5.1	4.8	5.3	7.0	4.4	6.5
Safer for passenger	5.4	5.0	<u>3.2</u>	4.0	3.0	4.1	3.8
Less congested	5.3	4.5	3.8	<u>3.9</u>	4.0	<u>3.2</u>	4.0
More available	3.3	<u>3.6</u>	4.4	4.0	2.8	3.8	3.0
More flexible	4.8	4.2	4.4	4.2	6.5	4.7	<u>2.2</u>
More relaxing	5.4	4.1	<u>3.1</u>	4.8	9.0	4.1	5.0
No drivers license	5.0	<u>3.4</u>	4.3	6.8	<u>1.4</u>	4.7	<u>2.3</u>
Car not available	3.7	3.8	3.6	5.0	<u>1.2</u>	4.4	<u>2.3</u>
(Total Number of Eligible Wives)	(102)	(89)	(18)	(20)	(13)	(47)	(29)

* The higher the number, the less important the reason.

Gave This Mean Rating to
These Reasons for Using
Public Transportation: *

Children Over 16 Years Old in These Cities:
New York Phila- Day- Phoe- Hous- Den- Los
delphia ton nix ton ver Angeles

Cheaper	3.5	3.8	3.0	-	-	2.2	1.5
Faster	3.8	3.0	1.0	-	-	2.0	7.0
More comfortable	6.3	5.9	-	-	-	5.7	9.0
Safer for passenger	6.0	4.7	-	-	-	4.7	10.0
Less congested	6.6	4.8	-	-	-	4.0	6.0
More available	2.7	3.1	1.7	-	2.0	2.2	4.0
More flexible	5.6	5.9	-	-	-	6.5	5.0
More relaxing	6.0	6.4	-	-	-	4.7	8.0
No drivers license	2.7	5.1	1.5	-	1.0	4.0	1.0
Car not available	3.5	4.3	1.0	-	2.0	2.8	2.0

(Total Number of Eligible Children)	(36)	(32)	(8)	(3)	(8)	(13)	(9)
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* The higher the number, the less important the reason.

3. REASONS FOR USING AUTO TRANSPORTATION

Household members were also asked to indicate their reasons for traveling by auto in a similar manner as they indicated their reasons for traveling by public transportation. The following three tables show the mean ranking given each reason by the various household member. Once again, eligible household members who did not rank a reason were excluded from the mean scores.

All household members in all seven cities are in agreement as to the most important reasons for traveling by auto. They travel by auto because it is faster, more flexible, and more available.

<u>Gave This Mean Rating to These Reasons for Using Auto Transportation: *</u>	<u>Husbands in These Cities:</u>						
	<u>New York</u>	<u>Phila- delphia</u>	<u>Day- ton</u>	<u>Phoe- nix</u>	<u>Hous- ton</u>	<u>Den- ver</u>	<u>Los Angeles</u>
Cheaper	4.7	5.1	5.2	5.3	5.7	5.7	5.5
Faster	<u>2.2</u>	<u>2.6</u>	<u>2.7</u>	<u>3.0</u>	<u>2.8</u>	<u>2.8</u>	<u>2.4</u>
More comfortable	3.2	3.9	4.4	4.5	4.6	4.6	4.8
Safer for passenger	5.9	6.3	6.6	6.3	6.6	6.7	6.5
Less congested	5.0	5.4	6.2	5.9	5.6	5.4	5.6
More available	<u>2.8</u>	<u>2.5</u>	<u>2.1</u>	<u>2.0</u>	<u>2.4</u>	<u>2.0</u>	<u>2.2</u>
More flexible	<u>2.8</u>	<u>2.4</u>	<u>2.5</u>	<u>2.3</u>	<u>2.4</u>	<u>2.6</u>	<u>2.6</u>
Need car during day	4.9	4.0	4.4	4.0	3.7	3.6	3.4
(Total Number of Eligible Husbands)	(123)	(149)	(81)	(144)	(142)	(175)	(159)

* The higher the number, the less important the reason.

<u>Gave This Mean Rating to These Reasons for Using Auto Transportation: *</u>	<u>Wives in These Cities:</u>						
	<u>New York</u>	<u>Phila- delphia</u>	<u>Day- ton</u>	<u>Phoe- nix</u>	<u>Hous- ton</u>	<u>Den- ver</u>	<u>Los Angeles</u>
Cheaper	5.2	5.3	4.8	5.3	5.8	5.7	5.4
Faster	<u>2.9</u>	<u>3.0</u>	<u>2.9</u>	<u>2.6</u>	<u>3.1</u>	<u>2.7</u>	<u>2.6</u>
More comfortable	3.1	3.9	3.8	4.6	4.2	4.8	4.6
Safer for passenger	5.7	6.3	6.4	6.1	6.5	6.6	6.4
Less congested	5.0	5.3	5.9	6.0	5.5	5.7	5.7
More available	<u>2.8</u>	<u>2.3</u>	<u>2.0</u>	<u>1.9</u>	<u>2.6</u>	<u>2.1</u>	<u>2.0</u>
More flexible	<u>2.9</u>	<u>2.2</u>	<u>2.3</u>	<u>2.2</u>	<u>2.2</u>	<u>2.3</u>	<u>2.2</u>
Need car during day	4.1	4.6	4.5	4.8	3.8	3.6	3.4
(Total Number of Eligible Wives)	(137)	(164)	(89)	(168)	(153)	(193)	(180)

* The higher the number, the less important the reason.

Gave This Mean Rating to
These Reasons for Using
Auto Transportation: *

Children Over 16 Years Old in These Cities:
New York Phila- Day- Phoe- Hous- Den- Los
delphia ton nix ton ver Angeles

Cheaper	5.5	5.5	4.9	4.2	5.6	5.4	5.5
Faster	<u>2.0</u>	<u>2.3</u>	<u>2.4</u>	<u>2.7</u>	<u>2.7</u>	<u>2.6</u>	<u>2.5</u>
More comfortable	3.5	3.7	3.7	4.7	4.4	5.4	4.6
Safer for passenger	6.8	5.7	6.0	5.3	6.4	6.1	6.2
Less congested	4.7	4.1	6.6	5.2	5.5	5.0	5.7
More available	<u>3.0</u>	<u>2.2</u>	<u>1.7</u>	<u>1.6</u>	<u>2.1</u>	<u>1.8</u>	<u>1.9</u>
More flexible	<u>1.7</u>	<u>2.3</u>	<u>2.8</u>	<u>1.7</u>	<u>2.0</u>	<u>1.7</u>	<u>2.0</u>
Need car during day	4.1	6.9	4.7	3.6	3.9	5.1	4.1
(Total Number of Eligible Children)	(44)	(52)	(30)	(60)	(58)	(55)	(63)

* The higher the number, the less important the reason.

PROPOSALS FOR ENCOURAGE USE OF PUBLIC TRANSPORTATION

Household members were asked to rate various proposals designed to encourage increased usage of public transportation facilities. Proposals were rated in the same manner as were the reasons for traveling by auto and public transportation. That is, the most effective proposal was rated "1", the next "2", etc. Means were calculated for each proposal on the basis of meaningful responses.

Household members in all seven cities feel that more frequent service would be one of the more effective ways of encouraging use of public transportation. Household members in New York would also include faster travel, lower fares and cleaner newer vehicles. Household members in Philadelphia and Dayton are similiar to those in New York in also considering faster travel and lower fares as being effective. Household members in Phoenix, Houston, Denver and Los Angeles feel that more conveniently located stops and stations is an effective way of encouraging use of public transportation. With the exception of Phoenix, household members in these cities would also include faster travel as an effective proposal.

It is interesting to note the similiarity between the most effective proposals for encouraging use of public transportation (faster travel, more frequent service and more conveniently located stops and stations) and the reasons for traveling by auto (faster, more flexible and more available).

<u>Gave This Mean Rating to</u> <u>These Ways of Encouraging</u> <u>Use of Public Transportation: *</u>	<u>Husbands in These Cities:</u>						
	<u>New</u> <u>York</u>	<u>Phila-</u> <u>delphia</u>	<u>Day-</u> <u>ton</u>	<u>Phoe-</u> <u>nix</u>	<u>Hous-</u> <u>ton</u>	<u>Den-</u> <u>ver</u>	<u>Los</u> <u>Angeles</u>
Cleaner/newer vehicles	3.8	4.8	4.8	6.1	5.8	6.5	6.0
Faster travel	3.2	3.8	3.6	4.1	3.5	3.5	3.4
Air conditioned vehicles	5.2	5.7	6.5	5.4	5.5	6.9	6.2
More frequent service	3.0	3.0	2.8	2.0	2.8	2.5	2.4
Lower fares	3.9	3.6	4.2	4.0	4.5	4.6	4.3
Parking facilities at stops and stations	5.8	4.6	4.7	5.3	4.9	4.5	4.6
Shelters against bad weather	6.2	6.3	5.7	6.2	5.3	5.5	5.6
Better security for personal safety	5.3	5.1	5.8	6.2	6.3	6.4	6.3
More conveniently located stops/stations	4.9	5.2	4.3	3.0	3.5	3.0	3.3
(Total Number of Eligible Husbands)	(132)	(153)	(84)	(148)	(146)	(178)	(161)

* The higher the number, the less effective the proposal.

<u>Gave This Mean Rating to</u> <u>These Ways of Encouraging</u> <u>Use of Public Transportation: *</u>	<u>Wives in These Cities:</u>						
	<u>New</u> <u>York</u>	<u>Phila-</u> <u>delphia</u>	<u>Day-</u> <u>ton</u>	<u>Phoe-</u> <u>nix</u>	<u>Hous-</u> <u>ton</u>	<u>Den-</u> <u>ver</u>	<u>Los</u> <u>Angeles</u>
Cleaner/newer vehicles	3.6	4.4	5.0	5.8	5.8	6.3	5.7
Faster travel	3.7	4.6	4.2	4.6	4.4	4.0	3.7
Air conditioned vehicles	5.2	5.8	6.4	5.3	5.5	6.5	5.6
More frequent service	3.1	3.2	2.5	2.3	3.0	2.5	2.5
Lower fares	3.7	3.6	3.9	4.0	4.2	4.6	3.9
Parking facilities at stops and stations	6.4	5.5	5.2	5.3	5.5	4.9	5.0
Shelters against bad weather	5.9	5.5	5.6	5.5	4.6	5.0	5.6
Better security for personal safety	4.4	4.3	5.5	6.1	5.4	6.1	5.9
More conveniently located stops/stations	5.2	5.0	4.0	2.9	3.7	3.3	3.5
(Total Number of Eligible Wives)	(163)	(174)	(96)	(175)	(161)	(202)	(188)

* The higher the number, the less effective the proposal.

<u>Gave This Mean Rating To These Ways of Encouraging Use of Public Transportation:</u>	<u>Children Over 16 Years Old In These Cities:</u>						
	<u>New York</u>	<u>Phila- delphia</u>	<u>Day- ton</u>	<u>Phoe- nix</u>	<u>Hous- ton</u>	<u>Den- ver</u>	<u>Los Angeles</u>
Cleaner/newer vehicles	<u>3.5</u>	5.2	5.0	5.5	5.5	6.3	5.8
Faster travel	<u>3.2</u>	4.0	<u>3.7</u>	4.3	4.0	<u>3.4</u>	<u>3.2</u>
Air conditioned vehicles	4.6	5.7	5.2	4.6	5.0	7.1	5.0
More frequent service	<u>3.0</u>	<u>3.0</u>	<u>1.9</u>	<u>1.7</u>	<u>2.3</u>	<u>3.1</u>	<u>2.2</u>
Lower fares	<u>3.5</u>	<u>2.7</u>	<u>2.3</u>	<u>3.4</u>	4.1	<u>3.7</u>	3.9
Parking facilities at stops and stations	6.0	6.2	5.4	6.6	6.1	5.4	5.0
Shelters against bad weather	5.6	5.1	5.3	6.1	4.7	5.4	6.7
Better security for personal safety	4.6	4.1	5.8	6.3	6.7	6.1	5.5
More conveniently located stops/ stations	6.4	6.0	5.0	<u>3.2</u>	<u>3.6</u>	3.7	<u>3.2</u>
(Total Number of Eligible Children)	(56)	(59)	(35)	(63)	(63)	(68)	(68)

* The higher the number the less effective the proposal.

DISPOSAL OF AUTOS OWNED

Respondents were asked if they would dispose of any of the cars they owned if better public transportation were available. Respondents in Denver and Los Angeles are more likely to dispose of a car or cars than respondents in any of the other cities. New York respondents are least likely to dispose of any cars. However, respondents in New York own fewer cars (1.2) than those in Denver and Los Angeles (1.8). In all cities the mean number of cars that would be disposed of is about 1.0.

When Asked If They Would
Dispose of Any of Their
Cars If Better Public
Transportation Were
Available Said:

This Percent of Respondents In These Cities:

	New York	Phila- delphia	Day- ton	Phoe- nix	Hous- ton	Den- ver	Los Angeles
	%	%	%	%	%	%	%
Yes	10	4	9	15	8	11	15
Maybe	10	21	17	13	19	23	16
No	80	75	74	72	73	66	69
Mean Number of Cars Owned	1.2	1.6	1.7	1.6	1.9	1.8	1.8
Mean Number of Cars Disposed	1.0	1.0	1.0	1.1	1.0	1.1	1.0
(Total Number of Respondents)	(164)	(178)	(99)	(178)	(163)	(204)	(193)



QUESTIONNAIRE

CONSUMER MAIL PANELS

323 SOUTH FRANKLIN STREET · CHICAGO, ILLINOIS 60606

(2-C796)

Dear Panel Member,

Today, I am sending you a questionnaire which I consider both exciting and interesting. Hopefully, you will too. This questionnaire deals with the important problem of air pollution caused by automobiles.

As you know, autos are a major source of air pollution—especially in metropolitan areas. You probably have read in newspapers or magazines that auto manufacturers are being required to make changes in their cars that will reduce the amount of pollutants coming out of cars. This will be particularly true for cars manufactured in 1975 and thereafter.

Many pollution experts believe, however, that despite these new federal regulations on auto air pollution, other ways will have to be found to further reduce pollution caused by cars. The purpose of this questionnaire is to obtain your reaction to these new auto pollution control ideas being suggested by the experts. In answering some questions, you will probably have to consult other members of your family to get their ideas and reactions. I am sorry if this is inconvenient, but I am sure you will agree that the importance of solving pollution problems is worth making every reasonable effort.

As always, please check each of your answers after you have completed the questionnaire. Then return it to me in the enclosed postage-paid envelope. If you have any additional comments, please write them on the lines provided in Question 11.

Cordially,



(2-C7-6)

AUTO AIR POLLUTION QUESTIONNAIRE

1. All autos made in 1975 and thereafter will be equipped with emission control devices to reduce air pollution. If in 1975 you owned a car built before that year, how would you feel about a law requiring you to put emission control equipment which might cost \$200 on your car? ("X" BELOW)
2. How would you feel about this law if the cost was reduced by government subsidy to about \$50? ("X" BELOW)

Feeling Toward Law:	1. Cost \$200	2. Cost \$50
Very much in favor of law . . .	☐ 1	☐ 1
Somewhat in favor of law . . .	☐ 2	☐ 2
Somewhat against law	☐ 3 (17)	☐ 3 (18)
Very much against law	☐ 4	☐ 4

- 3a. Even cars properly equipped with emission control equipment might still pollute the air if the equipment was not properly maintained. How would you feel about a law requiring periodic inspection of the emission control system to assure that it was working properly? ("X" ONE ONLY)

Very much in favor of law ☐ 1 Somewhat in favor of law ☐ 2 Somewhat against law ☐ 3 Very much against law ☐ 4

- 3b. Assuming you had to have your car inspected at least once a year, what would you consider a reasonable cost for the inspection? (WRITE IN AMOUNT)

\$ _____

- 3c. Assuming you had to have your car inspected at least once a year, where do you think the inspection should be made? ("X" ONE ONLY)

At state-operated inspection centers . ☐ 1
At city-operated inspection centers . . ☐ 2
At local service stations or garages . ☐ 3

At some other place (Specify): _____

- 4a. Even if all autos were equipped with properly maintained emission control systems, some cities might still have auto air pollution problems due to the large number of cars either on the streets at the same time or concentrated in particular areas. Listed below are several possible ways to reduce pollution under one or both of these conditions. Please tell me how you feel about each of these proposals. ("X" ONE ON EACH LINE)

Proposal:

- | | To Me This Plan Is: | | | | | |
|---|----------------------------|----------------------------|-------------------------------------|----------------------------|----------------------------|----|
| | Very Acceptable | Somewhat Acceptable | Neither Acceptable Nor Unacceptable | Somewhat Unacceptable | Very Unacceptable | |
| a. Gasoline rationing | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 | 23 |
| b. Very high (\$500) registration fee per auto. | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 | 24 |
| c. Very high (\$500) registration fee per auto but only for the second, third, etc., auto. | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 | 25 |
| d. Prohibit traffic and parking in central business districts | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 | 26 |
| e. A tax on <u>all day</u> parking in central business districts | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 | 27 |
| f. A tax on parking in central business districts regardless of whether a person parked only one hour or all day | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 | 28 |
| g. Tolls on exit ramps of major freeways and expressways | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 | 29 |
| h. Tolls on exit ramps of major freeways and expressways but only when traffic was heavy. | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 | 30 |
| i. Restrictions on non-essential auto travel during times of high pollution by issuance of special license plates or vehicle stickers | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 | 31 |
| j. Turn some existing lanes into "bus only" and "car pool only" lanes on major expressways and streets. | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 | 32 |
| 4b. Which of the proposals listed above would be the <u>most acceptable</u> ? (Give Letter:) | | | | | | 33 |
| 4c. Which would be <u>most unacceptable</u> ? (Give Letter:) | | | | | | 34 |

QUESTIONS 1-4 ASK FOR INFORMATION RELATING TO OTHER HOUSEHOLD MEMBERS. CONSULT THEM IF NECESSARY. FOR THE ANSWERS.

1a. How often do the various members of your household travel by public transportation? (For example, by bus, subway, or commuter train.)

	Husband	Wife	Children (Over 16 Years Old)
Three or more times a week	1	1	1
One or two times a week	2	2	2
Once a month	3	3	3
Once every three months	4	4	4
Never	5	5	5
No household member	6	6	6

1b. Please rate each household member's reason for using public transportation. (Rate the most important reason "1", the next most important "2", etc. If a household member never uses public transportation, "X" the "never use" box at the bottom of the list.)

1c. Please rate each household member's reasons for traveling by auto. Follow the same procedure as in Question 1b. (WRITE IN BELOW UNDER 2)

	Husband	Wife	Children (Over 16 Years Old)
1. Cheaper	(38)	(40)	(43)
2. Faster	(44)	(47)	(49)
3. More comfortable	(50)	(52)	(54)
4. Safer for passenger	(56)	(58)	(61)
5. Less congested	(62)	(65)	(67)
6. More available	(68)	(70)	(72)
7. More flexible (I can come and go as I please)	(15)	(17)	(20)
8. More relaxing (able to read while traveling)	(21)	(23)	(26)
9. Need car during the day	(Not Applicable)	(Not Applicable)	(Not Applicable)
10. I do not have a driver's license	(27)	(28)	(29)
11. Car is not available when I need it	(30)	(31)	(32)
12. Other (Specify):	(33)	(34)	(35)
13. Never use ("X" Box)	1	2	3

1d. Again, consulting other members of your household, please rate in order of effectiveness which items below you feel would be most effective in encouraging the use of public transportation. (Rate the most effective item a "1", the next most effective "2", the next "3", etc.)

	Husband	Wife	Children (Over 16 Years Old)
1. Cleaner and newer vehicles	(41)	(42)	(43)
2. Faster travel	(44)	(45)	(46)
3. Air-conditioned vehicles	(47)	(48)	(49)
4. More frequent service	(50)	(51)	(52)
5. Lower fares	(53)	(54)	(55)
6. Parking facilities at stops or stations	(56)	(57)	(58)
7. Shelters against bad weather at stops or stations	(59)	(60)	(61)
8. Better security to assure personal safety	(62)	(63)	(64)
9. More conveniently located stops or stations	(65)	(66)	(67)
10. Other (Specify):	(68)	(69)	(70)

(71-78 open)
79-80

6a. How would you or other household members feel about traveling to and from work in a car pool? ("X" ONE ONLY)

Very interested 1
Somewhat interested 2
Not at all interested 3
Already in car pool 4
Do not travel to and from work by car 5

6b. If it became necessary to restrict the number of cars on expressways and streets in order to reduce pollution and car pools became necessary, how difficult do you think it would be to get into one an existing one or organize one amongst your friends, neighbors and/or work associates. ("X" ONE ONLY)

Extremely difficult 1
Very difficult 2
Somewhat difficult 3
Somewhat easy 4
Very easy 5
Already in car pool 6

7. One of the major causes of areas of high pollution is traffic congestion. Pollution could be reduced if traffic congestion and stop-and-go traffic was reduced. Listed below are several ideas for reducing traffic congestion. Please tell me how effective you think each of these ideas would be in reducing congestion and pollution. ("X" ONE BOX FOR EACH IDEA)

Very Effective	Somewhat Effective	Not Effective At All	Would Increase Congestion
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- Prohibit parking, loading and unloading on busy streets
- Increase the number of one-way streets
- Establish reversible lanes on busy streets to be used during rush hours
- Prohibit turns at busy intersections during rush hours
- Widen major streets
- Widen major streets at intersections only
- Provide pedestrian underpasses and/or overpasses
- Improve timing of traffic signals
- Increase the number and frequency of radio traffic reports
- Turn some existing lanes into "bus only" and "car pool only" lanes on expressways and busy streets
- Your idea (Please List):

8. Since traffic congestion is most severe at times when people are going to or coming from work, one alternative for reducing congestion would be to have people start and stop work at different times of the day. That is, some people would start work at 5:00 AM and quit at 2:00 PM, others would work from 7:00 AM to 4:00 PM, others from 10:00 AM to 7:00 PM, etc. How do you feel about this idea? ("X" ONE ONLY)

Very much in favor 1
Somewhat in favor 2
Indifferent 3
Somewhat opposed 4
Very much opposed 5

(PLEASE CONTINUE ON THE NEXT PAGE)

- 9a. Please record the model year of each car owned in your household. (WRITE IN BELOW UNDER 9a)
- 9b. Please estimate the number of miles each car was driven in the last year. (WRITE IN NUMBER OF MILES UNDER 9b BELOW)
- 9c. For each car, please estimate what percentage of last year's mileage was accounted for by driving outside your local metropolitan area. (For example, vacation, business trips, short weekend trips, etc.) (WRITE IN BELOW UNDER 9c)

	9a. Model Year	9b. Last Year's Mileage	9c. Percentage of Mileage Outside Local Area		
Car #1	_____	_____	____%	29	
Car #2	_____	_____	____%	32	
Car #3	_____	_____	____%	35	
Car #4	_____	_____	____%	38	

- 9d. How many licensed drivers are there in your household? (WRITE IN)

Number of Licensed Drivers: _____

- 9e. If better public transportation were available, would you consider disposing of any of the cars you own?

Yes ☐ 1
 Maybe ☐ 2
 No ☐ 3

9f. How many? (WRITE IN) _____ cars

- 10a. Overall, how serious a problem do you think auto air pollution is in your city? ("X" ONE BOX UNDER 10a BELOW)

- 10b. Overall, how serious a problem do you think auto air pollution is nationwide? ("X" ONE BOX UNDER 10b BELOW)

	10a. City	10b. Nationwide
Very serious problem.	☐ 1	☐ 1
Serious problem.	☐ 2	☐ 2
Slightly serious problem.	☐ 3 (44)	☐ 3 (45)
No problem at all.	☐ 4	☐ 4

11. If you have any views or comments regarding any question or idea, please record them:

(46-78 open)

79-380

Thank you for your help. Please check your answers and then return the questionnaire to me in the enclosed postage-paid envelope.